EFFECT OF OCCLUSAL SPLINTS ON THE ACTION OF MUSCLES OF MASTICATION IN PATIENTS WITH TEMPOROMANDIBULAR JOINT DYSFUNCTION SYNDROME

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BRANCH III

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CHENNAI

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **"EFFECT OF OCCLUSAL SPLINTS ON THE ACTION OF MUSCLES OF MASTICATION IN PATIENTS WITH TEMPOROMANDIBULAR JOINT DYSFUNCTION SYNDROME"** is a bonafide record and genuine research work done by me under the guidance of **Dr. V. SATHYABAMA FDSRCS.,** Professor, Department of Oral & Maxillofacial Surgery, Ragas Dental College and Hospital, Chennai.

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CERTIFICATE

This is to certify that this dissertation titled **"EFFECT OF OCCLUSAL SPLINTS ON THE ACTION OF MUSCLES OF MASTICATION IN PATIENTS WITH TEMPOROMANDIBULAR JOINT DYSFUNCTION SYNDROME"** is a bonafide record of the work done by **Dr. AJIT.C,** under our guidance and to our satisfaction during his postgraduate study period **2016-2019.**

This Dissertation is submitted to **THE TAMILNADU Dr. MGR MEDICAL UNIVERSITY,** in partial fulfillment for the award of the Degree of **MASTER OF DENTAL SURGERY – ORAL AND MAXILLOFACIAL SURGERY, BRANCH III.** It has not been submitted (partial or full) for the award of any other degree or diploma.

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ABSTRACT

PURPOSE: The aim of this study was to evaluate the action of splint therapy on the muscles of mastication namely Temporalis and Masseter in patients with temporomandibular joint dysfunction syndrome using a muscle force transducer

MATERIALS AND METHOD: This is a prospective study in fifteen patients reporting to, Ragas Dental College and Hospital, Chennai, Out Patient diagnosed with untreated temporomandibular dysfunction syndrome between 18 and 60 years of age. All the patients included were in the early stages of the disorder and were only treated with a conservative approach by means of medications and splint therapy. Advanced stages of dysfunction was not included in this study as at least minimal surgical intervention would have been required. An MRI was done for these cases to rule out advanced stage of disease following which patient specific splints were provided. A muscle force transducer was attached over the masseter and temporalis muscles independently and the muscle activity was recorded at the time of presentation of the disorder, 1 month, 2 months and 3 months after delivery of the splints. Along with muscle activity gender prevalence, pain scores, severity of disorder, presence of impacted third molars, parafunctional habits and effectiveness of the treatment were also evaluated

RESULTS: The Study Revealed that TMJ dysfunction had a female predilection and was closely associated with patients having impacted third molars and parafunctional habits. An overall reduction in the pain score and muscle activity was seen in all the patients. Muscle activity values that reverted back to the normal range was seen in 14 of the 15 patients

CONCLUSION: It can be concluded that splints play an important role in relieving patients with TMJ dysfunction syndrome. The transducer can be used as an efficient diagnostic tool to record muscle activity and to objectively determine the duration of splint therapy rather than solely relying on subjective evaluations.

Key words: **Temporomandibular Joint, Transducer, Splints, Muscle Activity, Conservative management;**

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Introduction

INTRODUCTION

A joint or an articulation is any interface between two bones in the body. Joints are naturally constructed in a way to both provide physical support and allow different degrees of movement. One such complex joint is the temporomandibular joint, also known as the mandibular joint, is the union between the mandible, a single stable horseshoe shaped bone and the cranium which is also mechanically a single stable component. Thereby this joint can also be more accurately referred to as a craniomandibular articulation[1]. It is the most used diarthrodial joint (2 bony components – Mandibular condyle and glenoid fossa & articular eminence of the temporal bones) and is doubtful if any other joint is used as much as the temporomandibular joint and with such vigor.

The TMJ is a "Ginglymodiarthrodial joint" which allows for hinge and gliding movements of the mandible. This joint allows an array of movements in the mandible like mouth opening and closing, lateral excursions, protrusion and retrusion of the mandible. It is a bilateral synovial joint which forms an articulation between the squamous portion of the temporal bone and condylar head of the mandible. The right and left TMJ form a bicondylar articulation. They are of ellipsoid variety of joints with similarities to the knee joint. Similar to other synovial joints including disc, bone, fibrous capsule, synovial membrane, fluid and ligaments the unique differentiating feature of this joint is that the articular surfaces are covered by fibrocartilage instead of hyaline

cartilage. Movements of this joint are not only guided by muscular and ligamentous attachment, but also by the occlusion of the teeth and since both the joints are attached by the single horseshoe shaped mandibular bone, they do not move independently of each other.

The articular disk is the most important anatomic structure of the TMJ situated between the mandibular condyle and glenoid fossa of the squamous portion of temporal bone. The disc fills the space between the aforementioned bones. The disk is an ovoid structure which separates the joint into upper compartment (Fossa – Disk complex) responsible for Hinge movements and lower compartment (Disk – Condyle complex) responsible for gliding movements. The disc is composed of three parts – anterior band, intermediate zone and posterior band. The articular disc is an avascular, non-innervated fibrocartilage whereas the associated ligaments of the disc namely – anterior ligament, posterior ligament/bilamellar zone, discomalleolar ligament, medial and lateral collateral ligaments – are vascular, innervated and fibroelastic in nature[2]

The temporomandibular joint receives innervations mainly from the auriculotemporal branch of the mandibular division of trigeminal nerve and also innervations from the masseteric and deep temporal nerves are present. The articulating surfaces of the temporomandibular joint covered by the fibrocartilaginous disc which are avascular and non-innervated have significantly high capacity to withstand the effects of degenerative changes.

The joint capsule, bilamellar zone of articular disk, retrodiscal tissue and associated masticatory muscles are innervated by nerves which are responsible for pain and discomfort in the presence of temporomandibular joint dysfunction syndrome.

Temporomandibular joint dysfunction or disorder is an array of conditions characterized by pain and tenderness over Temporomandibular Joint region or associated structures, orofacial pain, pain during mouth opening, altered or restricted mandibular movements, temporomandibular joint sounds with or without pain, deviation/deflection of mandible during opening and closing of the mouth.

One of the earliest reports of temporomandibular disorders was described by ***Costen in 1934*** wherein he related loss of teeth leading to loss of vertical dimension with temporomandibular joint pain and ear pain.[3] Bell in 1967 suggested the term "Temporomandibular Disorders", Schwartz coined the term "Temporomandibular Joint Dysfunction Syndrome", Ash and Ramford later introduced "Functional Temporomandibular Joint Disorders" and Laskin proposed "Myofacial Pain Dysfunction Syndrome (MPDS). The varying terms suggest various etiologic factors, such occlusomandibular disturbances, myoarthropathy of the joint and some even provided evidence of pscychophysiologic disorder.[4] Numerous terms, numerous etiologies led to a great amount of controversy and confusion in a field of science which is already complex.

Prevalence of TMD's varies between 17% and 70%, a study conducted in Chennai by ***Saraswathi Gopal et al*** revealed that 52% of the population suffered from TMJ disorders.[5] ***Solberg et al in 1979*** stated that the most common symptom associated with TMD's was headache and women were more commonly affected than men. Subclinical signs were more frequently seen than the awareness of symptoms.[6]

Weinberg et al in 1980 stated that a common scientific method cannot be used for diagnosing TMD's as it is impossible to isolate variables due to its multifocal etiology thus clinical examination, subjective evaluation and patient signs and symptoms are the key factors for diagnosing TMD's and accurate case history recording is necessary.[7] Additional diagnostic aids are jaw tracking devices to assess Range of motion of mandible, electromyography can be used to detect abnormal muscle activity, high contrast ultrasonography is a developing useful tool for diagnosis of disc displacement but gold standard for locating the position of the disc is the MRI and also gives us information about the cartilage and retro-discal tissue, CT scans can be used for noting changes in osseous contour of articular eminence and the head of the condyle. Occlusal changes and disturbances can be recorded using a T scan. The distribution of time and force of occlusal load can be evaluated, this can help us screen occlusal stability in intercuspal position.

The treatment of TMD's has always been subject to debate and controversy, but consensus on the fact that in the treatment of these disorders first line of approach is always conservative by nature without invading tissues of face, jaw and joints. If left untreated symptoms can worsen and extend far beyond jaw and mouth area. Conservative therapy is always directed towards the nature and source of the cause for the dysfunction.

Tim Dylina in 2001 explained that muscle in coordination can be reversible if caught in time. The treatment involves usage of bite plane therapy or permissive splints as phase I therapy and Phase II therapy involving additive/subtractive occlusal therapy, restorations, orthodontic therapy etc. Muscle in coordination along with disc in coordination generally requires permissive splints as phase I therapy and stabilization splints in phase II therapy.[8]

Properly fabricated splints have at least 6 functions including the following (1) Relax the muscles associated with TMJ (2) Seat the condyle in centric relation (3) Provision of diagnostic information (4) Protect teeth and associated structures from extensive occlusal load, wear and tear (5) Mitigate proprioception in the periodontium (6) Reduces cellular hypoxia levels – in the retrodiscal regions mainly. But these splints are only effective in the early stages of dysfunction. Advanced muscle and disc in coordination generally is an irreversible state. The patient can be relived of pain temporarily with usage

of medications but splints are generally ineffective in these stages and the patient usually requires invasive methods of management.[8]

There are different types of occlusal appliances available today with each one having its own special design, indication and considerations that are to be followed with precision. It is of utmost importance for clinicians to completely understand the dynamic nature of the masticatory system and perform a complete examination of the TMJ and associated components and structures to provide the patients with the required appliance with minimal complications. It is also highly essential to take an accurate medical history as TMJ abnormalities are not always a separate entity and are more often associated with other systemic complications such as rheumatoid arthirits, ankylosisng spondylitis, patients on CNS depressants, etc.

The purpose of this study was to evaluate the action of the splints on the associated muscles of mastication, namely the masseter and temporalis, in patients with temporomandibular dysfunction syndrome.

Aims & Objectives

AIMS AND OBJECTIVES

AIM:

The purpose of this study was to evaluate the action of splint therapy on the muscles of mastication namely Temporalis and Masseter in patients with temporomandibular dysfunction syndrome

OBJECTIVE:

To record the change in the activity of the anterior temporalis and masseter muscles in patients with internal derangement of the TMJ using a transducer before and after conservative management with splint therapy

Review of Literature

REVIEW OF LITERATURE

James B. Costen[3] in 1934 was one of the first to describe the relation between TMJ function and changes in dentition and partial/complete edentulism. He stated that one of the most effective modalities in treatment of TMJ is the correction of occlusal disharmony and renewal of molar support. His article in which he says "Following group of symptoms may be associated with edentulous mouth and a marked overbite" was one of the first articles to relate dentistry and TMJ dysfunction which in turn paved a way for dentists to involve themselves in the treatment of temporomandibular joint dysfunction.

Welden E. Bell[9] in 1964 proposed four steps in a rationale treatment of TMD's. The first step involves establishment of an accurate diagnosis by identifying the changes and the cause for the changes in the joint and supportive musculature and to localise the area of change (Extracapsular, Intracapsular or Capsular). The second step is attempting to eliminate or neutralise the cause for the dysfunction which is mainly correction of occlusal disharmony and relieving the tenision within the joint which causes a decrease in interarticular clearance. The third step is to provide optimum conditions for natural recovery from the disorder by sparing the joint from abusive usage and providing the join adequate physiological rest. The final step is the application of specific forms of therapy with reason and purpose once the first three steps are done. This involves treating the extracapsular problem (Eg. Relief of myospasm), Capsular Problem (Relief from capsulitis) or the intracapsular

problem (Eg. Relief from joint effsuin, Increase interarticular space, etc.). This article aided doctors treating TMD's to compartmentalize and systematically treat the problem thereby providing efficient result to their patients.

Benjamin C. Moffett[10] et al in 1964 described the process of articular remodelling in response to functional stresses in the TMJ and its gradual progress into osteoarthritis. He stated that the histological picture of the TMJ is in correlation with its functional significance. The mechanical factors associated with function account for the gradual transformation fibrous articular tissue into fibrocartilage in postnatal life. He suggested that remodelling can also occur as a result of altered nutritional status to the joint and when the limits of remodelling are reached progression into osteoarthritis takes place.

C. J. Griffin et al[11] in 1971 elicited the hyperactivity of the reticular formation and in turn the hyperactivity of the masseter and anterior temporalis muscles in patients with temporomandibular dysfunction by conducting an EMG study by comparing the EMG activity of the aforementioned muscles in individuals without temporomandibular dysfunction. It was further stated that after the insertion of an occlusal splint the hyperactive nature reduces thereby indicating that occlusal splints are effective in treatment of certain temporomandibular disorders

Franco Mongini[12] in 1972 carried out microscopic study of 100 crania of both sexes between 18 and 67 years at death and stated that remodelling was prominent only in certain areas of condylar joint surface (Anterior and Posterior). Incidence of remodelling rapidly increased between 18 and 25 after which age has no significance. Remodelling increases as partial edentulism increases in severity.

William K. Solberg et al[6] in 1979 investigated the prevalence of mandibular dysfunction in young adults based on symptoms of internal derangement of the TMJ. He found that in a sample of 369 men and 370 women with an average age of 22.5 years joint sounds were present in 28.3% of the population. They have stated that parafunctional habits like lip biting, teeth grinding, teeth clenching and posturing of mandible are causative factors leading to TMJ dysfunction and were present in 7.9% of the sample population.

Charles C. Beard et al[13] in 1980 evaluated the effects of occlusal splint therapy alone in patients with TMJ dysfunction. In this study 486 pantograms were made on 15 patients with TMJ dysfunction over a period of 5 months to 1 year and a pantographic reproducibility index(PRI) was recorded. They concluded that occlusal splints do reduce the symptoms of TMJ dysfunction but they tend revert back to pre treatment stage of dysfunction following removal of the splint and the duration of splint

treatment increased with increase in severity of the dysfunction and also with longevity of the dysfunction.

Richard W. Katzberg[14] in 1983 evaluated condyle fossa relationships in patients with internal derangement of the temporomandibular joint by arthrographic methods. It was concluded that plain film radiography was insuffiecient for diagnosis of temporomandibular disorders especially if the abnormalities of meniscus function was the primary etiology.

P. Kirveskari[15] et al in 1985 studied the association between tooth loss and TMJ dysfunction. They concluded that the loss of the upper first premolar was closely associated with TMJ dysfunction and subsequent loss of teeth worsened the condition and it was of utmost importance to establish a good occlusion for relief from the TMJ abnormality.

D. C. Hatcher et al[16] in 1986 stated that TMJ dysfunction arised from loss of posterior teeth, dentoskeletal abnormalities and mandibular assymetries. These in turn resulted in excessive loading of the Temporomandibular joint either through excessive occlusal forces or increased forces from the muscles of mastication

Chong Shan[17] in 1989evaluated the activity of the masseter muscle with an EMG and measured bite force in patients with temporomandibular dysfunction. They concluded that muscle activity was increased in TM

dysfunction patients and surface electrodes can be used to diagnose muscle disorders

Wright[18] in 1991 put forward that temporomandibular dysfunction patients develop tension relieving oral habits when facing stressful situations which in turn leads to myospasm, pain and worsens the jaw dysfunction thereby aetiology of TMD's is not only physiological but also psychological thus it is imperative to consider the latter's importance while formulating a treatment plan.

Lund et al[19] in 1995 emphasized that TMD's are diagnosed mainly through clinical examination and additional diagnostic aids and no specific tests have been developed to actually confirm the dysfunction and screening tests like electromyography, thermography, jaw tracking, electrical stimulation etc are not very specific and only add to an increase in healthcare costs thereby main aim should only be to alleviate the pain and provide relief to the patient rather than attempt to do these tests.

Stanley Braun et al[20] in 1995 used a transducer to evaluate the bite force in patients and it was noted that bite force even in patients with temporomandibular disorders wasn't significantly different from patients without TMJ dysfunction which meant that unless a discomfort threshold was reached in patients with TMJ dysfunction bite force is not altered.

Fernandez Sanroman et al[21] in 1998 studied the relationship between condylar position and dentofacial deformities with or without incidence of Temporomandibular joint dysfunction. This was one of the earliest studies not only dependant on clinical examination but also used arthrography and MRI to evaluate the condyle and disc position. They concluded that patients with class II malocclusion tend to have an higher incidence of tempromandibular disorders than those in Class I or Class III occlusion. In all of the cases with temporomandibular dysfunction a retropositioned condyle was noted with decreased superior joint space.

Mongini et al[22] in 2001 attempted to differentiate between myogenus facial pain and temporomandibular joint pain using the Mcgill Pain Questionnaire (MPQ) and Visual Analogue Scale(VAS). The data when analysed showed the discriminative capacity of the MPQ and all MPQ subscales. Moreover, within the same item, the number of words chosen and choice of verbal descriptors carried consistently between the 2 patient groups.

Tim Dylina[8] in 2001 reviewed the action and various types of splints used in the treatment for TMD's. Splints were grouped into permissive (Allow unimpeded movement of teeth) and non permissive splints (Position and secure the mandible anteriorly and inferiorly). It was stated that splints when properly fabricated have 6 functions : Relax muscles, allow condyle to seat in centric relation, provision of diagnostic information, protect teeth and associated structures from parafunctional habits, mitigate periodontal ligament

proprioception and reduce cellular hypoxia levels, He also narrowed on the type of splint to be used for specific form of dysfunction.

Rudiger Emshoff et al[23] in 2002 compared the efficacy of sonography imaging with MR imaging for patients with temporomandibular dysfunction. This study included 64 patients (128 joints) all of which were subjected to High resolution sonography during maximum range of mandibular motion and subsequently MR imaging. The author concluded that MRI was gold standard for imaging of the disc but in cases where a MRI is not feasible or available, high resolution sonography was able to provide almost similar results (93% accuracy) in diagnosing disc displacement but there was always a chance of false positive results if the transducer was not positioned properly.

Major et al[24] in 2002 did a study using MRI to see the relation between disc position and disc deformation by relating normal TMJ characteristics and TMJ internal derangement in 335 subjects. It was concluded that as disc displacement increases and disc length decreases, Superior joint space decreases and Anterior and posterior joint space increases.

Rahul Srivatsa et al[25] in 2003 performed a review of literature and evaluated the effect of the revolutionary fluid system splint The Aqualizer™. They stated that conservative management was best as a first line approach in

treating patients with TMD's and The Aqualizer^{TM}is a floating action, muscle relaxing form of splint therapy which provides the best patient compliance, is easy to make and is a highly cost effective form of treatment when compared to surgical techniques

Melchiorre et al[26] in 2003 assessed and compared the efficiency of MRI and Ultrasonography of the TMJ involved in rheumatoid and psoriatic arthirits. In a Caucasian population of 11 females and 22 males thereby including 66 joints it was noted that though the disc displacement was more evident with an MRI evaluation join effusions and bony alterations of the condyle and the fossa was more evident in the USG. Thereby due to its cost effective nature and ability to do more repetitions USG could be a more valuable tool for diagnosis of advanced stages TMD's.

Jens C. Turp et al[27] in 2004 evaluated the efficacy of stabilization splints in patients with masticatory muscle pain and concluded that stabilization splints are highly effective in immediate relief of symptoms and recovery from the dysfunction but there in no evidence of long term stability.

Truelove et al[28] in 2006 described that 2 main types of splint therapy was available – Occluding and non occluding. Occluding splints are stabilization splints used mainly for alignment of the upper and lower teeth. Non occluding splints also called simple splints, open up the jaw and prevent

occlusion thereby releasing muscle tension and teeth clenching. Non occluding splints are generally cheaper to make and are of a soft vinyl nature.

C. Alpaslan et al[29] in 2008 evaluated the efficacy of soft and hard splints following arthrocentesis. Soft/Hard splint therapy are effective conservative methods in treatment of TMJ disc displacement with reduction but in cases of displacement without reduction wherein surgical approaches are warranted arthrocentesis was the first line of treatment. In a sample of 45 patients out of which 22 were given hard splints following procedure, 9 were given soft splints and 14 were without a splint. No significant differences were noted in reduction of pain and mouth opening after arthrocentesis even if a splint was not given. Thus, once a TMD has been warranted a surgical management conservative management was not necessary following the surgical procedure unless habits of bruxism or clenching were present.

Sandra Girgis et al[30] in 2008 evaluated the success of conservative management in TMD's. A retrospective study inclusive of a sample of 186 patients was done and it was put forward the most common complaint was pain and clicking noise and 97% of these patients did not receive any advice on conservative treatment until referral to an OMFS unit. She concluded that TMD's are common and can be treated conservatively at a general medical or dental practitioner level and treatment need not be delayed unless symptoms persist even after conservative therapy.

Wang et al[31] in 2008 stated that the highest prevalence of Temporomandibular disorders was noticed more in women between the ages of 20 – 40 years. They comprise of 80% of patients being treated for TMD.

T. I. Suvinen et al[32] in 2008 evaluated the outcome of conservative management of temporomandibular pain dysfunction syndrome in 42 patients (39 Women and 3 Men). They were able to bring about a moderate effect on relief of the dysfunction syndrome through conservative management and described the importance of psychological and psychosocial factors in Temporomandibular pain dysfunction syndrome. Treatment of this dysfunction syndrome should not be just directed at the physiological factors but also the psychological factors in order to give a long term and effective relief from the syndrome

Andrew J. Sidebottom[33] in 2009 put forward that when treating a tempormandibular joint dysfunction the TMJ surgeon should have a complete armamentarium of conservative approaches in avoiding TMJ surgery. Appropriate measures to alleviate pain are to be undertaken and only if conservative measures fail and an appropriate diagnosis and treatment can be surgically made then a surgical solution maybe sought.

Yadav. S[34] in 2011 stated that dental occlusal splint has been the mainstay of treatment for TMD's. According to him "Occlusal splint therapy maybe defined as art and science of establishing neuromuscular harmony in

the masticatory system by creating a mechanical disadvantage for parafunctional forces with removable appliances". The occlusal splint is a relaxing, diagnostic, reversible repositioning device with the main goal to improve jaw muscle function by creating a stable balanced occlusion.

Elahyes et al[35] in 2012 observed a sample of 37 patients (16 males and 21 Females) suffering from myofascial pain dysfunction, internal derangement of the TMJ or anterior disc displacement with reduction and all of them were given a soft acrylic splint of 2mm thickness and followed up for 4 months. All of them showed a positive response and it was concluded that soft splint therapy as a night guard provides good long term relief.

Seifeldin & Elhayes[36] in 2015 evaluated the effectiveness of soft and hard occlusal splints in treatment myofacial pain and internal derangement of the TMJ with reciprocal clicking. All 50 patients were limited to early stages of disc displacement with a negative history of locked jaw or had a history of muscle tenderness or myofacial pain. Pain intensities were measured using a boley gauge to measure comfortable range of mouth opening and a visual analogue scale was used to record pain intensity. On usage of the splints both the groups showed a marked improvement in mouth opening, pain, relief of clicking sounds, facial pain and tenderness but the signs of improvement were more prominent in patients using the vacuum pressed soft splint than the hard acrylic splint.

Daniel Talmaceanu[37] in 2015 compared various imaging techniques of the TMJ and put forward that imaging necessity is purely based on need. Osseous changes are suspected CT is preferred, MRI is the gold standard for visualizing the disc and high resolution ultrasonography is a potentially promising, cost effective, diagnostic aid for assessing TMJ disc position

Alquatabi & Aboalrejal[38] in 2015 classified oral appliances for treatment of TMD's into Flat plane Stabilization splint (Michigan Splint), Traditional Anterior bite planes, Mini Anterior Appliances, Anterior/Orthopaedic Repositioning appliance, Neuromuscular Appliance, Posterior Bite plane Appliance, Pivot Appliance and Hydrostatic Appliances

Bristela et al[39] in 2016 evaluated temporomandibular joints with anterior disc dislocation without reposition using an MRI over a period of 4 to 8 years. The MRI was very effective and till date remains the gold standard for capturing position, mobility and morphology of the disc and the condyle effectively and allowed for evaluation of adjacent structures. They also stated that the 3 Tesla appeared superior compared to those with a lower field strengt in the same examination time. The MRI was also efficacious in evaluating retrodiscal fibrosis and "Pesudo-Disc" formation.

Jens. C Turp et al[40] in 2016 assessed position of articular disc with relation to condyle, position of condyle in relation to temporal joint surfaces and depth of glenoid fossa of temporomandibular joints in 72 patients using an

MRI and reinterpreted the clinical significance of the findings. Reinterpretation reveals that lot in many asymptomatic cases we do see change in position of disc or findings like flattening of disc these could either be variance from normalcy or adaptive changes without any physiological disturbance thereby MRI's are to be considered only an aid in the diagnosis and decisions are to be related clinically following which appropriate treatment plans are to be fabricated

Kaan Orhan et al[41] in 2016 researched the efficacy of MRI in TMD's. This retrospective study involved a systematic review of 10 years of research on MRI and TMD's. The results ranged from 25.3-69 % for findings with TMJ with sound, 17-74.5% for TMJ with functional limitation, 13.3-77% in TMJ with pain. Main reason for variations was that certain findings were seen in asymptomatic patients as well thereby MRI cannot be used as a single deciding factor for diagnosis for TMD's and has to be used in conjunction with clinical presentation.

Sarah Sheik[42] in 2017 performed a prospective study in new patients reporting with TMD's and stated that soft splints were effective methods of first line therapy in conservative management of TMD's and generally improves the patients compliance to further treatment if required and this compliance is owing to the initial reduction from symptoms such and pain and muscular tenderness.

Hosgor et al[43] in 2017 compared 4 minimally invasive approaches for treatment of anterior disc displacement of the TMJ. A sample of 40 patients were evenly split into 4 groups (Occlusal splint therapy, Arthrocentesis, NSAID Therapy and low level laser therapy). It was noted that the mouth opening showed a major improvement in patients receiving arthrocentesis therapy and pain intensities reduced maximum and faster in patients with Low level laser therapy. But over a period of 6 months treatment with the occlusal splints and arthrocentesis showed better relief and less recurrence of symptoms.

Jovana Pficer et al[44] in 2017 performed a meta-analysis on the short and long- term effects of occlusal stabilization splints for patients with TMD's. 33 Randomized controlled trials were analysed and it was put forward that the stabilization splints had an overall positive effect on pain control in the short term when compared with occluding or non occluding splints whereas in the long term there was no major differences in pain control irrespective of the type of splint used. In the long term stabilization splints had a positive outcome on reduction of muscle tenderness and improvement in mouth opening.

Tatli et al[45] in 2017 compared the effects of, Arthrocentesis only, Splint therapy following arthrocentesis and Splint therapy only, in cases of TMJ disc displacement without reduction. It was concluded that arthrocentesis only was effective for reduction of pain and functional impairment and splint

alone was not useful in cases of disc displacement without reduction and did not have much of an additive effect even with usage of splint after arthrocentesis

Materials and Methods

MATERIALS AND METHODS

Source of Data:

This study was conducted in Ragas dental college and hospital in the department of oral and maxillofacial surgery during the period of December 2016 to November 2018. The protocol for this study was accepted by the institutional review board (IRB) on December 2016. The study population consisted of 15 patients diagnosed with untreated temporomandibular dysfunction between 18 – 60 years of age. The criteria for inclusion and exclusion are as follows:

Inclusion Criteria:

- Patients in stage I and II of Wilke's classification of internal derangement
- Pain in and around TMJ region
- Pain and tenderness over masticatory muscles
- Intermittent locking of the TMJ
- Joint sounds
- Patients between ages of 18 – 60 years

Exclusion Criteria:

- Patients in stages III, IV and V of Wilke's classification of internal derangement
- Patients with cognitive impairment
- Patients who have missing teeth with loss of posterior occlusion
- Patients with other systemic illnesses such as osteoporosis, rheumatoid arthritis, ankylosing spondylitis, osteoarthritis and previous history of trauma
- Patients who have undergone orthognathic surgery, surgery of the TMJ
- Patients on medications such as anti-psychotics and anti-depressants.

Design of Study:

- Prospective Study
- Study of effect of splints in clinical series of 15 patients

Case Report & Informed Consent Form – A standard TMJ questionnaire was used to record data on each subject during the course of the study. A visual analogue scale (VAS) was used to record the subjective pain evaluation and the study was explained verbally to all the patients in their native language and a written informed consent was obtained before their inclusion in the study

Armamentarium:

- Metal stock impression trays
- Irreversible hydrocolloid
- MRI of the TMJ
- Transducer – Novatek Automation
- Muscle sensor surface electrodes – Covidien™
- Arduino 1.8.7 - Open source software for receiving transducer values
- CamStudio™ – Open source screen recording software
- Patient specific Splints

Muscle Transducer:

A Force transducer was specifically designed for this study to evaluate the muscle activity by Novatek, Hosur. The transducer consists of an Arduino microcontroller which is powered by an external system like a laptop or desktop which is also used for reading the data. 3 surface electrodes red, black and blue are present. The red and black electrodes are attached to the muscle whose activity is to be measured (Masseter or Temporalis) and the blue electrode is a reference electrode attached on the forearm or bicep.

The 3 electrodes are connected to an analog input in the microcontroller. This input is converted into a digital output in an external system with an Arduino

1.8.7 open source software and finally the digital output obtained is recorded using the CamStudio™ open source software

Magnetic Resonance Imaging :

Temporomandibular joint disorders are best evaluated with MRI. It is the most effective way to visualize the articular disc, locate its exact position in an open and a closed mouth, with reference to the condylar head and articular eminence, as well as accurately observe the morphological features of the disc. Additional findings which can be evaluated in the MRI include retro-discal tissue rupture, disc perforations, thickening of attachment of the lateral pterygoid muscle and joint effusion, thereby MRI serves as a tool to diagnose disc displacement and aids us in staging the severity of the dysfunction. In this study, MRI was used as an additional aid to clinical examination to view the position of the disc displacement (Anterior/Posterior) and to exclude participants who showed signs of advanced dysfunction. The MRI used for this study is a 1.5T, Echelon Oval, Hitachi. Sagittal T1 weighted proton density fat saturation was performed on all subjects with 3mm slice thickness and axial scout images were obtained to identify the condyles.

Splint Therapy:

Conservative management is considered the first line of therapy in treatment of temporomandibular dysfunction. Splints provide diagnostic information, position condyles in centric relation, normalize periodontal proprioception and relax muscles which are in spasm. Based on the nature of

disorder splints are chosen. In the presence of parafunctional habits like bruxism alone with no muscle or disc disturbances soft splints are considered an efficacious mode of treatment.

In cases of muscular disturbances alone bite planes are generally preferred where as in cases of muscular disturbance and disc in coordination stabilization splints or deprogrammer splints are given. In this study splints were given for the patients in accordance with the dysfunction present after careful evaluation of the dental, muscular and joint systems.

Methodology :

- The patients reporting with a complaint of pain or discomfort in and around the TMJ region or associated structures to the Ragas Dental OP were carefully examined by taking a detailed case history
- A through clinical examination of the TMJ and associated structures were done. This involved a bilateral palpation over the TMJ region at rest and during mandibular movements
- If the patient satisfied the inclusion criteria, the entire study protocol was explained to the patient and an informed consent was obtained. The patient was then considered as a participant in the study conducted at ***Ragas Dental College and Hospital***
- The participants of this study were first asked to fill up a visual analogue scale scoring chart at the first sitting of history taking.

- Following which they answered questions about TMD symptoms in the Fonseca Questionnaire
- During the examination:
    1. Presence of orofacial pain/ headaches were noted
    2. Mouth opening was measured in millimeters
    3. Deviation or deflection of the mandible was checked
    4. Clicking/crepitus in joint was identified and assessed
    5. Locking of joint was evaluated
    6. Pain in associated muscles of TMJ were checked
    7. Medical history was assessed
    8. Dental history was evaluated'
    9. Presence/Absence of para-functional habits were checked
- Once the detailed case history and examination was completed the selected participants were advised to take an Orthopantamogram to evaluate local dental issues prevailing that needed to be attended to.
- The morphology of condyles, their symmetry and any conditions that required treatment were looked into. The presence or absence of wisdom teeth that could contribute to orofacial pain was also assessed.
- Patients who required removal of their impacted wisdom teeth were dealt with after the acute phase of temporomandibular dysfunction syndrome subsided.

- Medical histories of the patients were also evaluated keenly to rule out other causes of TMJ dysfunction. Cardiac history was taken with precision to determine the presence of stents or implanted devices before going in for a MRI scan
- On the first day when case history recording was done, if the patient was in an acute phase of dysfunction, Analgesics and Muscle relaxants were given to settle the condition following which the patient was called subsequently for assessing the muscle activity using a transducer
- The transducer is initially adapted to the patient on the forearm to assess the working, once the patient was well explained about the principles and functioning of the transducer the readings were recorded on the computer and also given to the patient before delivering the oral splint. The Masseter and Anterior Temporalis were the muscles evaluated.
- The first transducer reading (T0) prior splint therapy is taken separately for the masseter and anterior temporalis muscles.
- The patient was asked to clench his/her teeth, the bulk of masseter is then palpated on both sides and the 2 electrodes (Red and Black) are placed, the third blue electrode which is the reference electrode is placed on the forearm. Once the output system is ready and recording software Camstudio^{TM}had been set up the participant was asked to follow the below mentioned four instructions:

1. Open the mouth
2. Close the mouth
3. Right lateral excursion
4. Left lateral excursion

- Upon performing the required mandibular movements, the output values and graphs were recorded and saved as T0
- Likewise the anterior temporalis was then palpated during clenching of the teeth and in a similar manner the recorded output values and graphs were saved as T0
- Once the T0 values were recorded impressions and models were poured for construction of an appropriate splint that was required for that particular patient
- All the selected participants were advised to take a MRI of the TMJ to rule out advanced stage of dysfunction. They were asked to record the anatomy of the TMJ both in open and closed state. The glenoid fossa with the condylar component interposed by the articular disc was imaged using a 1.5T MRI.
- Following which the patient specific splint was delivered.
- Transducer values were recorded for masseter and anteriortemporalis muscles at 1 month(T1), 2 months(T2) and 3 months(T3) after delivery of the patient specific splint

TMJ CASE SHEET

CASE RECORD

Date:

NAME:

IP NO:

AGE/SEX:

Occupation:

A) Duty timings -

B) Type Of Job -

RELIGION:

ADDRESS:

TEL NO:

CHIEF COMPLAINT:

HISTORY OF PRESENT ILLNESS:

HISTORY OF TRAUMA:

HISTORY OF PAIN

A) DURATION:

B) SITE OF PAIN:

C) FREQUENCY:

Occasional:

Constant:

Regular time:

D) TYPE:

E) AGGRAVATING FACTOR:

F) RELIEVING FACTOR:

G) RADIATING:

Sharp L/R:

Dull L/R:

Sharp L/R + Dull L/R:

CONCOMITTANT NEUROLOGIC SIGNS:

LIMITATION OF MOVEMENT:

A) Nil :

B) Early morning:

C) End of day only :

D) Varies:

E) Constant :

HISTORY OF CLICKING:

A) Left :

B) Right :

C) Left +Right:

RESTRICTION IN MOUTH OPENING:

PARAFUNCTIONAL HABITS:

A) TOOTH CLENCHING

B) TOOTH GRINDING

C) CHEWING SIDE – Right/Left/Central

PAST MEDICAL HISTORY:

HABITS:

PAST DENTAL HISTORY:

PERSONAL HISTORY:

GENERAL EXAMINATION

A) GENERAL ASSESMENT:

B) MENTAL STATE:

C) BUILD & STATE OF NUTRITION:

D) COLOUR OF SKIN:

E) PULSE:

F) RESPIRATION:

G) TEMPERATURE:

H) BLOOD PRESSURE:

LOCAL EXAMINATION

A) FACE: SYMMETRICAL/ASYMMETRICAL

B) RANGE OF MOVEMENT OF JAW:

C) INCISAL OPENING:

D) LATERAL EXCURSIONS:

E) DEVIATION:

F) TMJ TENDERNESS:

G) CREPITUS

TMJ SOUND

A) Click: Single / Multiple

B) Click: Early / Late

C) Click: Soft / Loud

D) Click: Panful / Not Painful

TMJ LOCKING:

A) OPEN / CLOSED:

B) TIME OF ONSET:

C) PATTERN:

MUSCLE TENDERNESS:

A) MASSETER:

B) TEMPORALIS:

C) LATERAL PTERYGOID:

D) MEDIAL PTERYGOID:

E) ACCESSORY MUSCLES OF MASTICATION:

F) EXAMINATION OF NECK MUSCLES:

LIP EXAMINATION

INTRA ORAL EXAMINATION

A) TEETH PRESENT:

B) MISSING TEETH:

C) FRACTURE TEETH:

D) CARIES TEETH:

E) RESTORED TEETH:

F) WASTING DISEASES OF TEETH:

G) TEETH MOBILITY:

H) POSTERIOR OCCLUSAL ATTRITION (BRUXISM SIGN)

I) OTHER FINDINGS

SOFT TISSUE EXAMINATION:

A) BUCCAL MUCOSA

B) LATERAL BORDER OF THE TONGUE

OCCLUSION:

A) INTERCUSPAL POSITION:

B) FREE WAY SPACE:

C) OVERJET:

D) OVERBITE:

E) PREMATURE CONTACT:

F) MAXIMUM MOUTH OPENING WITH OUT PAIN OR NOISE:

G) MAXIMUM MOUTH OPENING:

H) RELATIONSHIP OF THE ANTERIOR TEETH:

I) OPENING / CLOSING MOVEMENT:

J) EXCURSIVE GUIDANCE:

PROVISIONAL DIAGNOSIS:

RADIOGRAPHIC EVALUATION:

A) OBLIQUE MANDIBLE:

B) OCCLUSAL:

C) DENTAL:

D) PA JAWS:

E) OPG:

F) OCCIPITOMENTAL:

G) REVERSE TOWNE'S VIEW:

H) LATERAL SKULL:

I) TRANSPHARYNGEAL VIEW:

J) MRI

DIFFERENTIAL DIAGNOSIS:

FINAL DIAGNOSIS

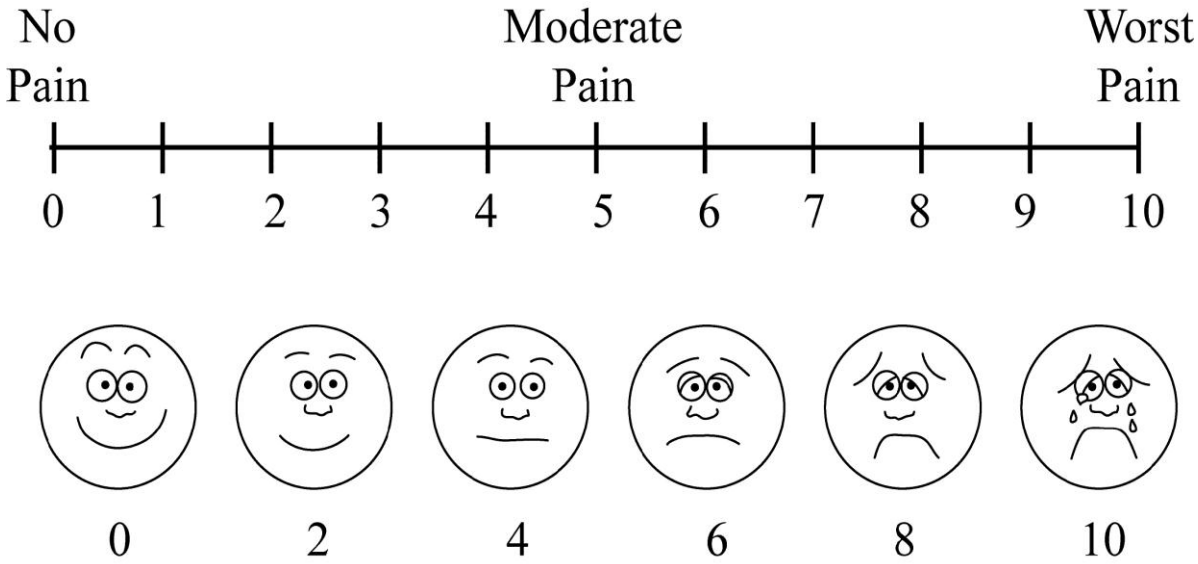
FONSECA QUESTIONNAIRE

S.No	QUESTIONS	NO	YES	SOMETIMES
1.	Is it hard for you to open your mouth?			
2.	Is it hard for you to move your mandible from side to side			
3.	Do you get tired/ muscular pain while chewing?			
4.	Do you have frequent headaches?			
5.	Do you have pain on the nape or stiff neck?			
6.	Do you have ear or temporomandibular joint pain			
7.	Have you noticed any clicking sound when chewing or opening your mouth			
8.	Do you clench or grind			
9.	Do you feel your teeth don't articulate well			
10.	Do you consider yourself a tense or nervous person			
		(0)	**(10)**	**(5)**

Fonseca Amnestic Index:

- Values of 0 - 15 : No TMD
- Values of 20 – 40 : Mild TMD
- Values of 45 – 65 : Moderate TMD
- Values of 70 - 100 : Severe TMD

VISUAL ANALOGUE SCALE (VAS)



Score Before Treatment	Score 1 month After Treatment

WILKE'S CLASSIFICATION OF INTERNAL DERANGEMENT

STAGE	CLINICAL FEATURES	IMAGING
I - EARLY	PAINLESS CLICKING; UNRESTRICTED FUNCTION	MILD DISC DISPLACEMENT; NORMAL CONDYLE
II – EARLY INTERMEDIATE	INTERMITTENT PAINFUL CLICKING AND LOCKING	MILD DISC DISPLACEMENT AND DEFORMITY; NORMAL CONDYLE
III - INTERMEDIATE	FREQUENT JOINT PAIN AND LOCKING; PAINFUL RESTRICTED FUNCTION; CHEWING DIFFICULTIES	MODERATE DISC DISPLACEMENT AND DEFORMITY; NORMAL CONDYLE
IV – INTERMEDIATE LATE	CHRONIC PAIN AND RESTRICTED MANDIBULAR FUNCTION	SEVERE DISC DISPLACEMENT AND DEFORMITY; ABNORMAL CONDYLE
V – LATE	SEVERE JOINT DYSFUNCITON (CREPITUS) WITH VARIABLE PAIN	SEVERE DISC DISPALCEMENT WITH PERFORATION AND DEFORMITY; DEGENRATIVE CHANGES IN CONDYLE

CONSENT FOR PARTICIPATING IN THE STUDY

TITLE OF THE STUDY: EFFECT OF OCCLUSAL SPLINTS ON THE ACTION OF MUSCLES OF MASTICATION IN PATIENTS WITH TEMPOROMANDIBULAR DYSFUNCTION SYNDROME

NAME OF THE PARTICIPANT:

NAME OF WITNESS:

I HAVE BEEN EXPLAINED ABOUT THE NATURE AND DETAILS OF THIS STUDY. I COMPLETELY UNDERSTAND THAT THE TRANSDUCER DEVICE AND MAGNETIC RESONANCE IMAGING ARE ESSENTIAL DIAGNOSTIC REQUIREMENTS FOR EFFICIENTLY TREATING MY PRESENT CONDITION. I AM WILLING TO UNDERTAKE THE TREATMENT PLAN EXPLAINED THOROUGHLY TO ME AND I HEREBY WITH COMPLETE CONSCIOUSNESS I AGREE TO BE A PART OF THIS STUDY.

SIGNATURE OF THE PARTICIPANT:

SIGNATURE OF WITNESS:

Figures

FIG 1: MUSCLE FORCE TRASNDUCER

(TOP – BLUE CABLE – OUTPUT TO COMPUTER; MIDDLE – BLACK BOX – TRASNDUCER; BOTTOM – COLOURED CABLES - TRASNMISSION FOR SURFACE SENSOR ELECTRODES)

FIG 2: CASE 1 – DISC DISPLACEMENT WITH REDUCTION

FIG 2A: FRONTAL VIEW

FIG 2B: RESTRICTED MOUTH OPENING

FIG 2C: INTRA ORAL VIEW

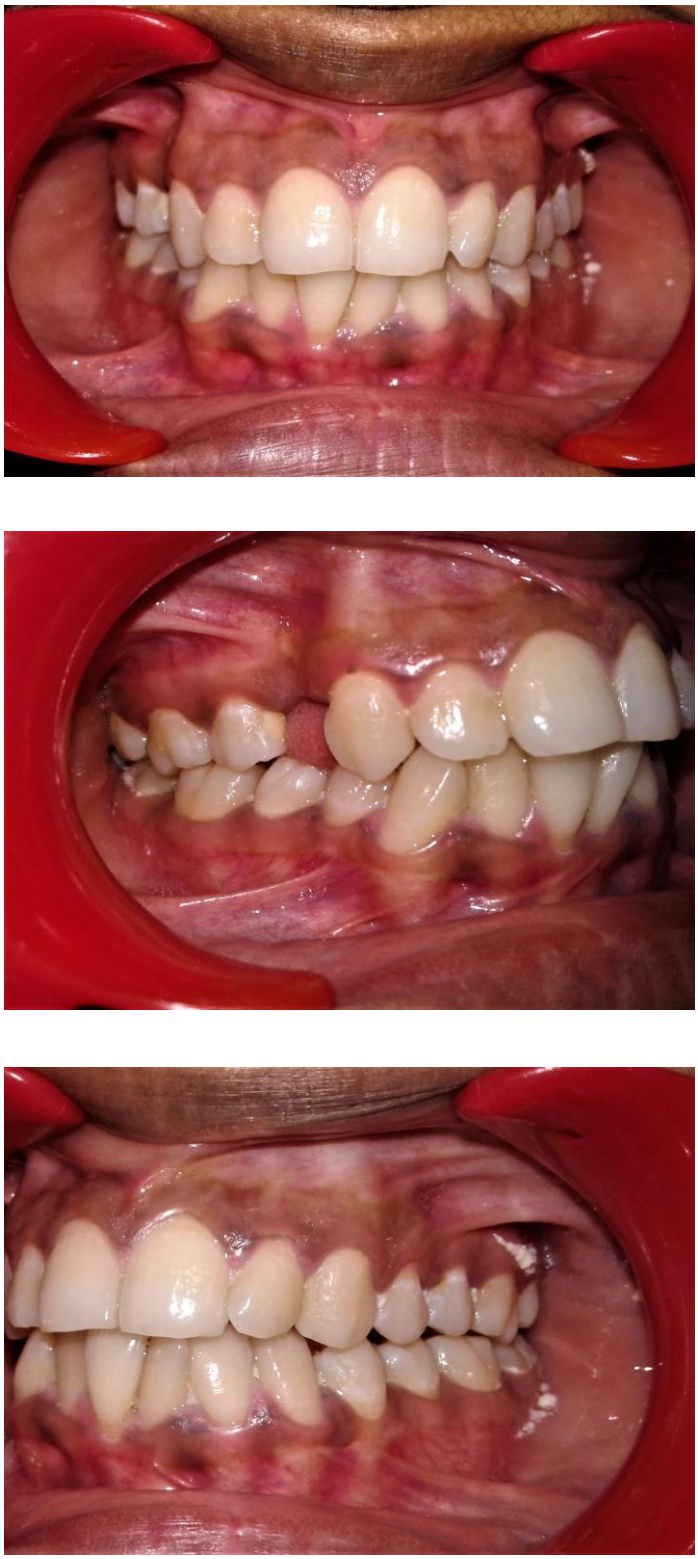


FIG 2D: MRI OF THE TMJ

FIG 3: CASE 2 – DISC DISPLACEMENT WITH REDUCTION

FIG 3A: FRONTAL VIEW

FIG 3B: RESTRICTED MOUTH OPENING

FIG 3C: INTRA ORAL VIEW

FIG 3D: MRI OF THE TMJ

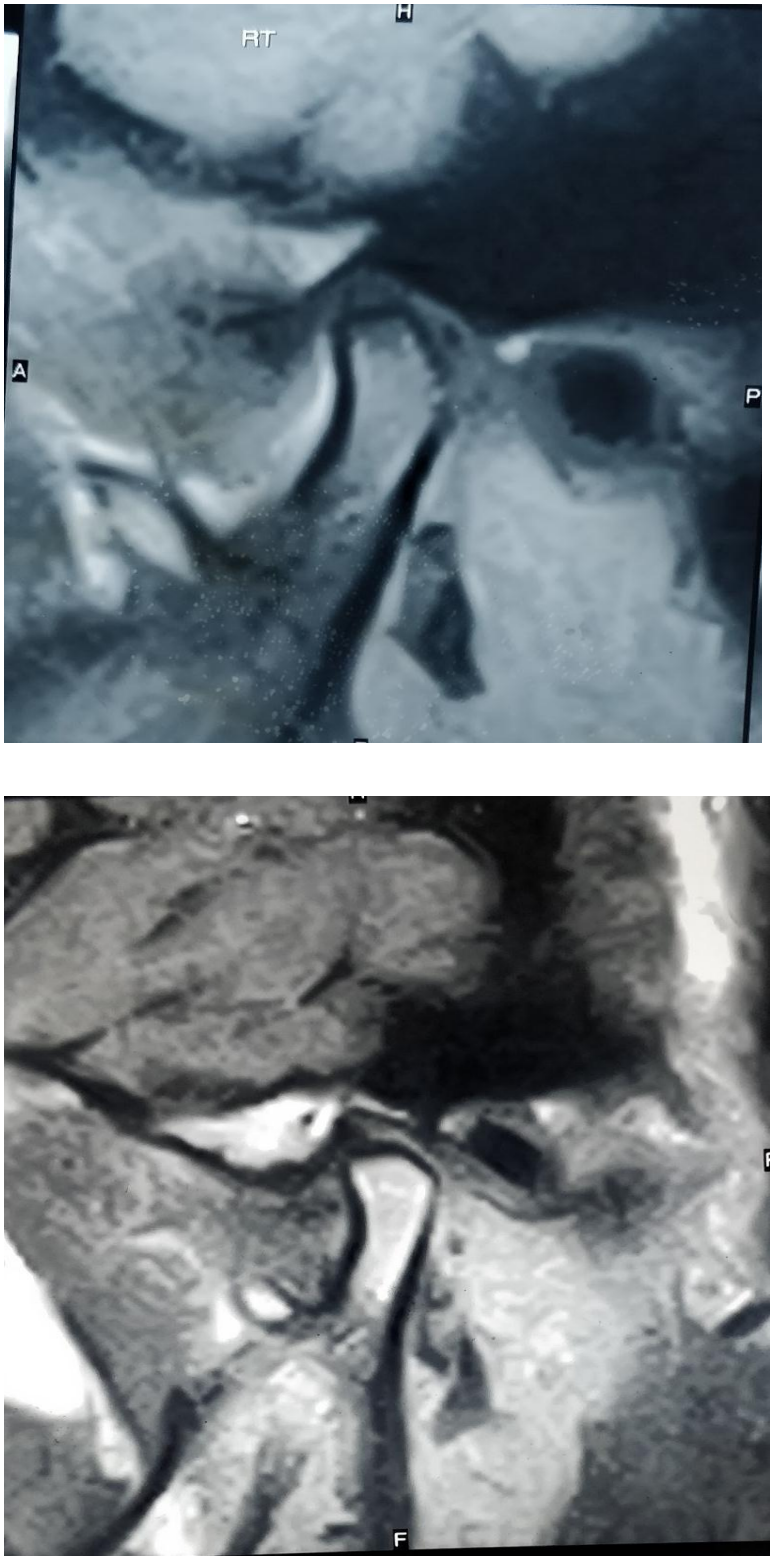


FIG 4: CASE 3 – DISC DISPLACEMENT WITH REDUCTION

FIG 4A: FRONTAL VIEW

FIG 4B:

RESTRICTED MOUTH OPENING

FIG 4C: MRI OF THE TMJ

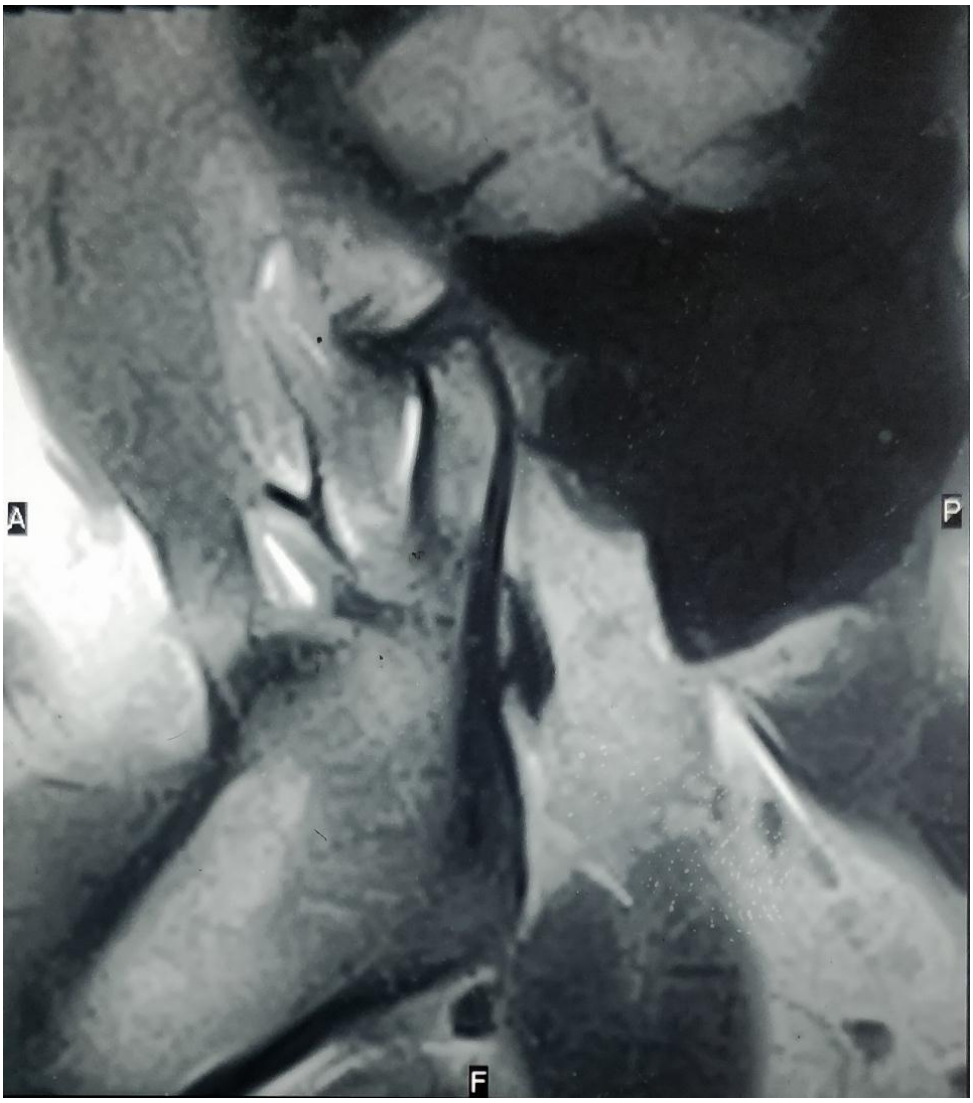


FIG 5: TRANSDUCER ANALYSIS OF THE ASSOCIATED MUSCLES OF TMJ

FIG 5A: ANALYSIS OF THE MASSETER MUSCLE

FIG 5B: ANALYSIS OF THE TEMPORALIS MUSCLE

FIG 5C: REFERENCE ELECTRODE (BLUE) ATTACHMENT OVER THE FOREARM/BICEP

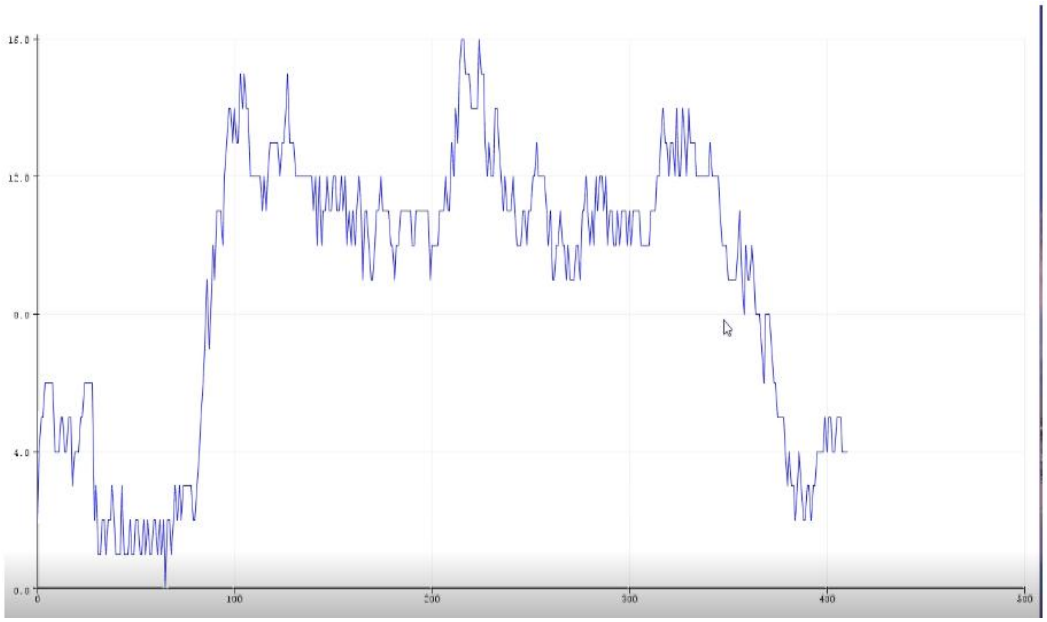
FIG 6: PATIENT SPECIFIC DEPROGRAMMING SPLINTS

FIG 6A: CASE 1

FIG 6B: CASE 2

FIG 7: FABRICATED DEPROGRAMMING SPLINT

FIG 8: ANTERIOR TEMPORALIS MUSCLE ACTIVITY SEEN WITH A TRANSDUCER



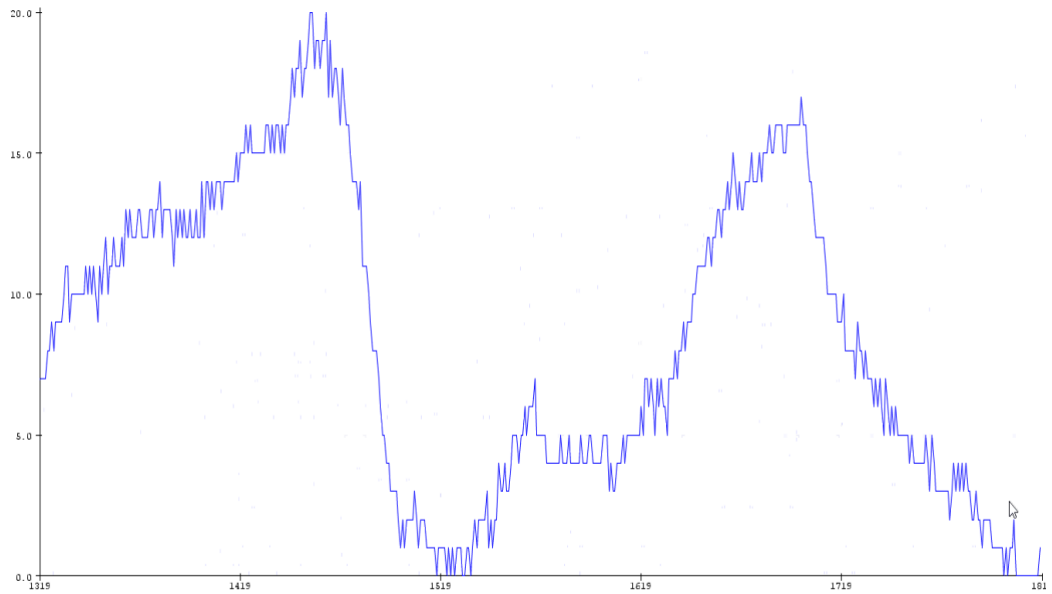
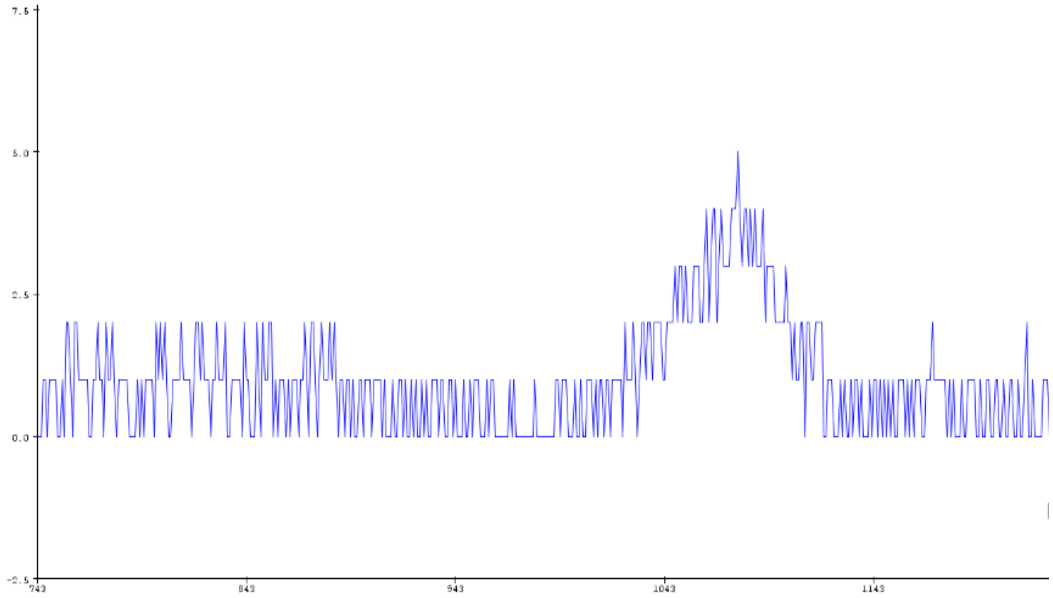
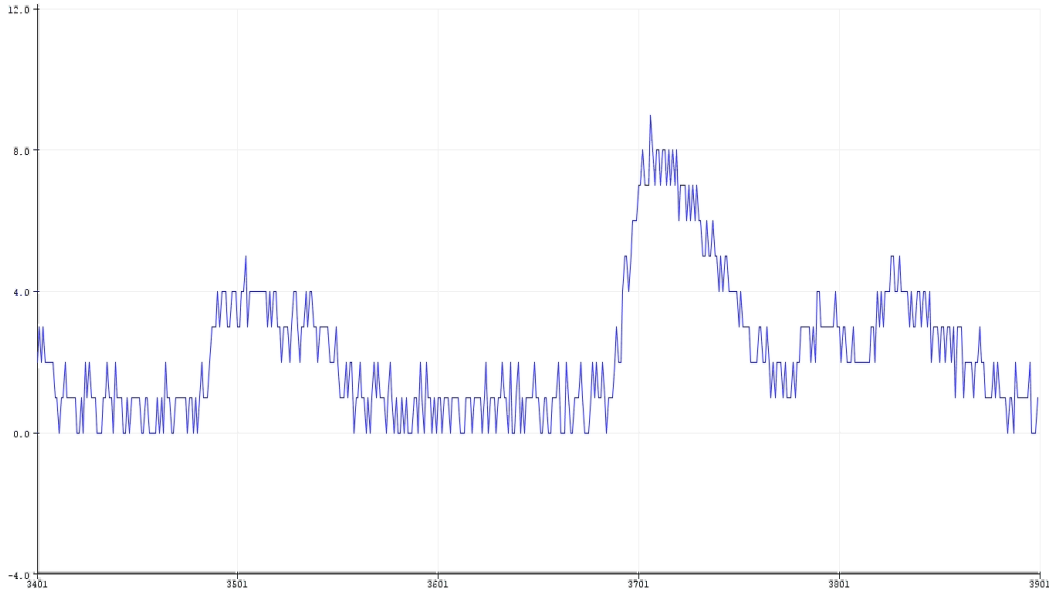


FIG 9: MASSETER MUSCLE ACTIVITY SEEN WITH A TRANSDUCER





Results

RESULTS

This study was conducted in Ragas dental college and hospital in the Department of Oral and Maxillofacial Surgery during the period of December 2016 to November 2018. The study was designed to evaluate the effect of splints on the muscles of mastication in patients with TMJ dysfunction syndrome using a force transducer and evaluating the muscle activity changes prior to and after commencement of splint therapy for up to 3 months. The association between genders, parafunctional habits, impacted third molars, occlusal pattern and TMJ dysfunction were also evaluated. A visual analogue scale, Fonseca questionnaire and MRI were used in conjunction with the transducer to diagnose and treat the patients satisfactorily. This study was conducted in 15 patients who were diagnosed as previously untreated early TMJ dysfunction syndrome. All the patients satisfied the inclusion criteria of the study.

Statistical Analysis: (If P-Value is <0.05 then statistically significant)

The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks tests results reveal that the variables (Masseter & Anterior Temporalis muscle readings) follow Normal distribution. Therefore to analyze the data parametric methods are applied. To compare the mean values between variables recorded at different time point, repeated measures of ANOVA is applied. An ANOVA with repeated measures which is used to compare group means where the study participants are same in each group. If sphericity assumption is violated

then Greenhouse-Geisser method is used to calculate the p-value. To analyze the data EPI-INFO (version 7.2.2.6, CDC, license: public domain) is used. Significance level is fixed as 5% ($\alpha = 0.05$)

Distribution of Study Subjects according to Age and Gender: (Table 1, Graph 1)

In the study population of 15 subjects 10 participants were women accounting to 66.7 % of the population and 5 participants were men accounting to 33.3 % of the population. Among these participants 4 were between 18 – 26 years of age (26.6 %), 7 were between 27 – 35 years of age (46.6 %), 3 were between 36 - 43 years of age (20%) and 1 was between 52 – 60 years of age (6.66%) and the mean age group of the participants was 30.86

Distribution of Study subjects according to presence of Impacted 3rd Molars: (Table 2, Graph2)

In the study 80% of the sample population had impacted third molars present accounting to 12 participants and only in 3 participants (20%) impacted 3rd molars were not present**.**

Distribution of study subjects according to nature of dental occlusion: (Table 3)

In the 15 participants 66.7% (10) had Angle's class II malocclusion, 20% (3) had Angle's class I malocclusion and 13.3% (2) had Angle's class III malocclusion.

Distribution of study subjects according to Wilke's staging of Internal Derangement and Type of Splint Used: (Table 4, Graph 5)

Out of the sample population 13 patients were in stage II (86.6%) of Wilke's staging of internal derangement and a deprogramming splint was given in these cases and 2 patients were in stage I (13.3%) and a soft splint was used in these cases.

Distribution of study subjects according to Fonseca's Criteria: (Table 5)

In the 15 participants the minimum Fonseca score was 25.0 and maximum was 65.0 with the mean Fonseca amnestic index score at 49.0 (Moderate TMD)

Distribution of study subjects according to presence of Parafunctional habits: (Graph 3)

12 patients who had TMD out of the sample 15 had parafunctional habits like bruxism, clenching, lip or fingernail biting. This amount to 80% of the population and only 20 % (3 participants with TMD) did not exhibit any signs or provide a history of parafunctional habits.

Visual Analogue Scale: (Table 6)

The visual analogue scale had a mean score of 6.2 at the time of presentation of the complaint with a maximum at 9.0 and minimum at 2.0 but 1 month after splint therapy the mean score dropped to 2.06 with 1.0 as the minimum score and 5.0 as the maximum.

Temporalis Muscle Transducer Analysis: (Graph 6)

T_0 - The minimum was 8.8 and maximum 21.2 with a mean of 10.327. The skewness was at 3.101 and kurtosis at 10.851

T_1 – Minimum was 8.4 and maximum 14.8 with a mean of 8.767. The skewness was at 1.801 and kurtosis at 4.96

T_2 - Minimum value was 7.8 and maximum was 11.3 with a mean of 8.44. The skeweness was at 1.832 and kurtosis at 4.681

T_3 – Minimum value was 7.7 and maximum was 11.1 with a mean of 8.43. The skeweness was at 2.844 and kurtosis at 9.591

For a unimodal distribution, negative skew commonly indicates that the *tail* is on the left side of the distribution, and positive skew indicates that the tail is on the right. In T0 the distribution is said to be left-skewed, left-tailed, or skewed to the left. In T1, T2,T3 the distribution is said to be right-skewed, right-tailed, or skewed to the right.

In T0 and T1, the kurtosis is below 3 (any univariate normal distribution is 3). It is common to compare the kurtosis of a distribution to this value. Distributions with kurtosis less than 3 are said to be ***platykurtic*.** In T3 and T4 the kurtosis is greater than 3, distributions with kurtosis greater than 3 are said to be ***leptokurtic*.**

These values reveal that, as the sample population is smaller in size the values are not uniformly distributed but rather are focussed around a single value.

Masseter Muscle Transducer Analysis: (Graph 7)

T_0 -The minimum was 6.1 and maximum 12.6 with a mean of 6.46. The skewness was at -0.714 and kurtosis at 0.560

T_1 – Minimum was 4.8 and maximum 8.5 with a mean of 5.413. The skewness was at 0.543 and kurtosis at 1.052

T_2 - Minimum value was 4.8 and maximum was 7.2 with a mean of 5.167. The skeweness was at 2.33 and kurtosis at 7.062

T_3 – Minimum value was 4.7 and maximum was 7.1 with a mean of 5.20. The skeweness was at 3.101 and kurtosis at 10.851

For a unimodal distribution, negative skew commonly indicates that the *tail* is on the left side of the distribution, and positive skew indicates that the tail is on the right. In T0 the distribution is said to be left-skewed, left-

tailed, or skewed to the left. In T1,T2,T3 the distribution is said to be right-skewed, right-tailed, or skewed to the right

In T0 the kurtosis is below 3 (any univariate normal distribution is 3). It is common to compare the kurtosis of a distribution to this value. Distributions with kurtosis less than 3 are said to be ***platykurtic***. In T2,T3 and T4 the kurtosis is greater than 3, distributions with kurtosis greater than 3 are said to be ***leptokurtic*.**

These values reveal that, as the sample population is smaller in size the values are not uniformly distributed but rather are focussed around a single value

General Linear Model for Temporalis Muscle: (Graph 8)

The Temporalis baseline point has mean value of 15.20 (SD ± 3.08), at time interval of 1 month the mean value is 10.32(SD ± 1.52), at time interval of 2 months the mean value is 8.76 (SD ± 0.86), at time interval of 3 months the mean value is 8.44 (SD ± 0.80).The repeated measures ANOVA result shows that these four mean distance values are statistically significant (p=0.000, Sig).Since there were no multiple comparison group in this study, the Greenhouse-Geisser was taken into account for assumption of normality, which was met and statistically significant, p-value of less than 0.05 (~0.00).Thus the value of Temporalis has minimum estimated marginal mean at 3 months when compared to baseline, at 1 month and at 2 months.

General Linear Model for Masseter Muscle: (Graph 9)

The Masseter baseline point has mean value of 9.70(SD ± 1.79), at time interval of 1 month the mean value is 6.46(SD ± 0.88), at time interval of 2 months the mean value is 5.41 (SD ± 0.57), at time interval of 3 months the mean value is 5.16 (SD ± 0.57).The repeated measures ANOVA result shows that these four mean distance values are statistically significant (p=0.000, Sig).Since there were no multiple comparison groups in this study, the Greenhouse-Geisser was taken into account for assumption of normality, which was met and statistically significant, p-value of less than 0.05 (~0.00).Thus the value of Masseter has minimum estimated marginal mean at 3 months when compared to baseline, at 1 month and at 2 months.

Tables and Graphs

EVALUATED DATA OF PATIENTS IN THE STUDY

S.No	AGE(In Years)	SEX	WILKE'S STAGING	VAS SCORE		FONSECA'S CRITERIA	IMPACTED 3RD MOLARS
				Before Rx	1 month After Rx		
1	32	F	II	8	2	60	PRESENT
2	39	F	II	8	3	60	PRESENT
3	59	M	II	6	3	45	NOT PRESENT
4	26	F	II	7	2	55	PRESENT
5	27	F	I	2	1	25	PRESENT
6	32	M	II	6	2	50	NOT PRESENT
7	28	M	II	6	1	50	PRESENT
8	35	F	II	8	3	55	PRESENT
9	29	F	II	7	2	50	PRESENT
10	19	M	II	6	1	45	PRESENT
11	37	M	II	7	1	50	PRESENT
12	28	F	II	4	1	40	NOT PRESENT
13	36	F	II	7	3	50	PRESENT
14	18	F	II	9	5	65	PRESENT
15	18	F	I	2	1	35	PRESENT

	TRANSDUCER VALUES								
PARAFUNCTIONAL HABITS	**MASSETER**				**TEMPORALIS**				**Type Of Splint**
	T0	T1	T2	T3	T0	T1	T2	T3	
PRESENT	11.2	6.4	5.2	5.3	18.7	10.3	9.1	8.1	Deprogramming
PRESENT	11.9	6.7	5.5	5.2	17.4	11.2	9.5	8	Deprogramming
PRESENT	10.2	6.1	5.9	5.1	16.6	10.4	8.6	8.5	Deprogramming
PRESENT	10.8	7.4	4.8	4.8	16.8	11.1	8.8	8.7	Deprogramming
NOT PRESENT	6.1	5.8	5.4	4.9	8.8	8.4	8.5	8.4	Soft Splint
PRESENT	9.8	5.7	5.2	4.7	14.3	9.7	8.1	7.9	Deprogramming
PRESENT	10.1	7.3	5.5	5.2	16.1	10.8	9.1	8.7	Deprogramming
PRESENT	10.5	7.2	5.2	5.1	16.7	11.3	9.3	8.6	Deprogramming
PRESENT	9.7	6.1	5.6	5	14.5	9.5	7.9	7.9	Deprogramming
NOT PRESENT	9	5.8	5.3	4.9	13.8	8.8	8.2	8.3	Deprogramming
PRESENT	9.8	6.3	5.4	5.4	14.5	10.2	8.1	8	Deprogramming
PRESENT	8.2	6.1	4.9	4.8	13.5	9.4	8.7	8.6	Deprogramming
PRESENT	9.4	6.7	5.2	5.1	14.9	10	8.5	8.1	Deprogramming
PRESENT	12.6	8.5	7.2	7.1	21.2	14.8	11.3	11.1	Deprogramming
NOT PRESENT	6.3	4.8	4.9	4.9	10.2	9	7.8	7.7	Soft Splint

TABLE 1: DISTRIBUTION OF STUDY SUBJECTS ACCORDING TO AGE AND GENDER

AGE (IN YEARS)	MALE		FEMALE		TOTAL	
	No.	%	No.	%	No.	%
18 - 26	1	6.6	3	20	4	26.66
27 - 35	2	13.33	5	33.33	7	46.66
36 - 43	1	6.67	2	13.33	3	20
44 - 51	0	0	0	0	0	0
52 - 60	1	6.66	0	0	1	6.66

TABLE 2: DISTRIBUTION OF STUDY SUBJECTS ACCORDING TO PRESENCE OF IMPACTED

3^{RD} MOLARS:

3^{RD} MOLARS	FREQUENCY	%
NOT PRESENT	3	20
PRESENT	12	80
TOTAL	15	100

TABLE 3: DISTRIBUTION OF SUBJECTS ACCORDING TO ANGLE'S MALOCCLUSION

OCCLUSION	FREQUENCY	%
CLASS I	3	20
CLASS II	10	66.7
CLASS III	2	13.3
TOTAL	15	100

TABLE 4: DISTRIBUTION OF STUDY SUBJECTS ACCORDING TO WILKE'S STAGING OF INTERNAL DERANGEMENT AND TYPE OF SPLINT USED

WILKE'S STAGING	TYPE	%
I	SOFT SPLINT	13.3
II	DEPROGRAMMING SPLINT	86.6

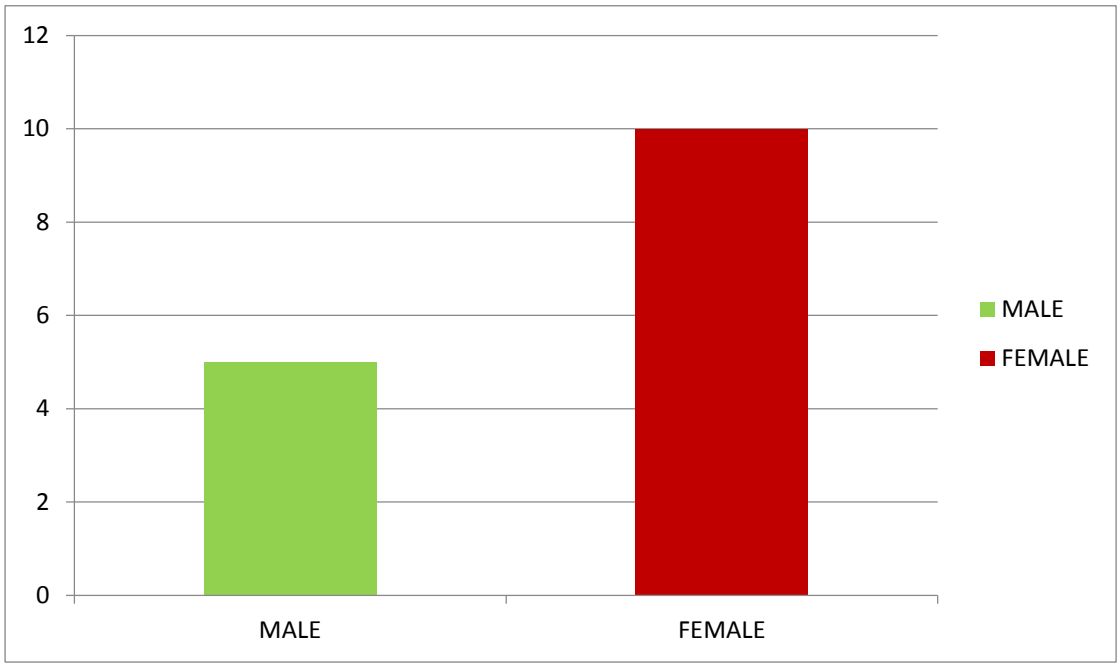
TABLE 5: DISTRIBUTION OF STUDY SUBJECTS ACCORDING TO FONSECAS ANAMNESTIC INDEX

	MINIMUM	**MAXIMUM**	**MEAN**
FONSECA ANAMNAESTIC INDEX	25.0	65.0	45.0

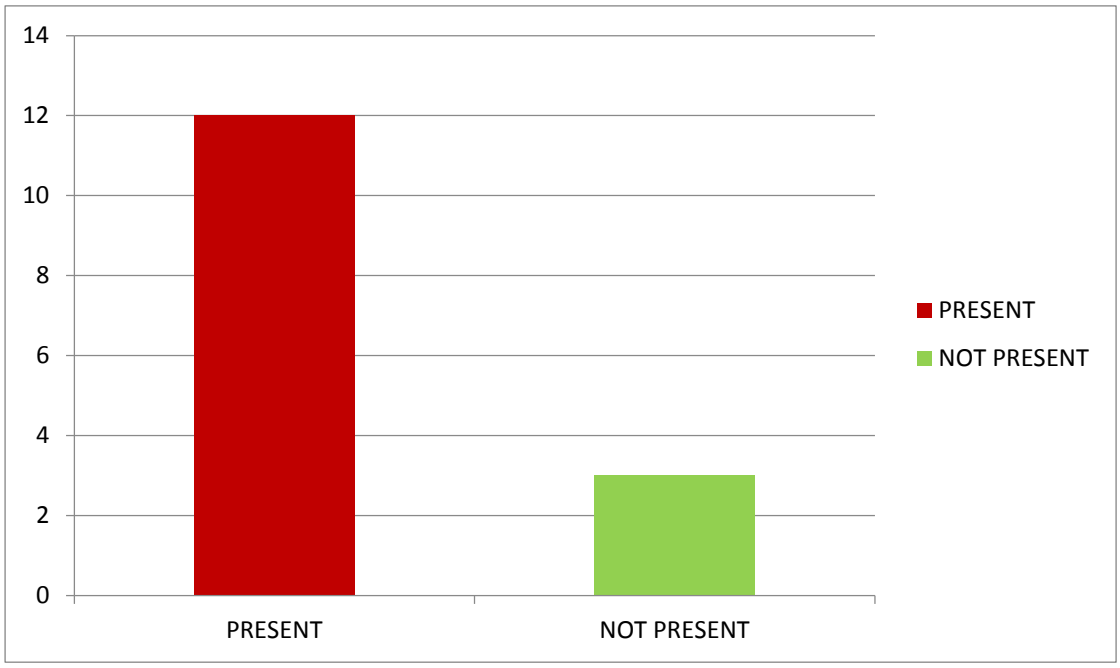
TABLE 6: VAS SCORE COMPARISON BEFORE AND AFTER TREATMENT

BEFORE TREATMENT			**AFTER TREATMENT**		
MINIMUM	MAXIMUM	MEAN	MINIMUM	MAXIMUM	MEAN
9.0	2.0	6.2	1.0	5.0	2.06

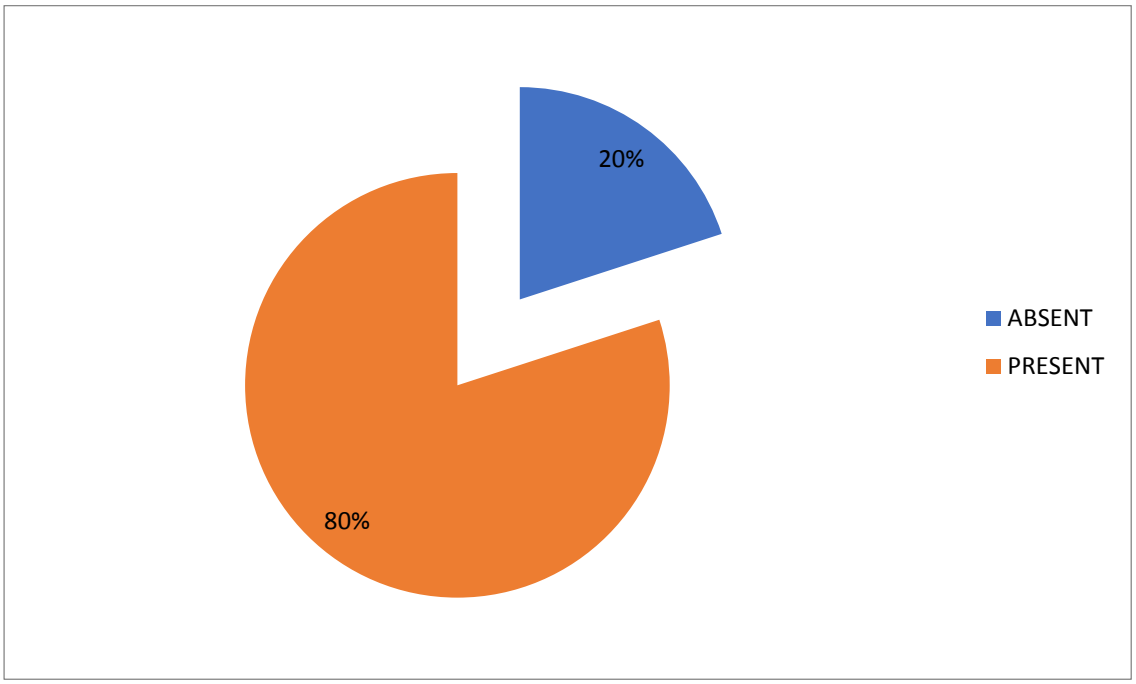
GRAPH 1: GENDER DISTRIBTUION



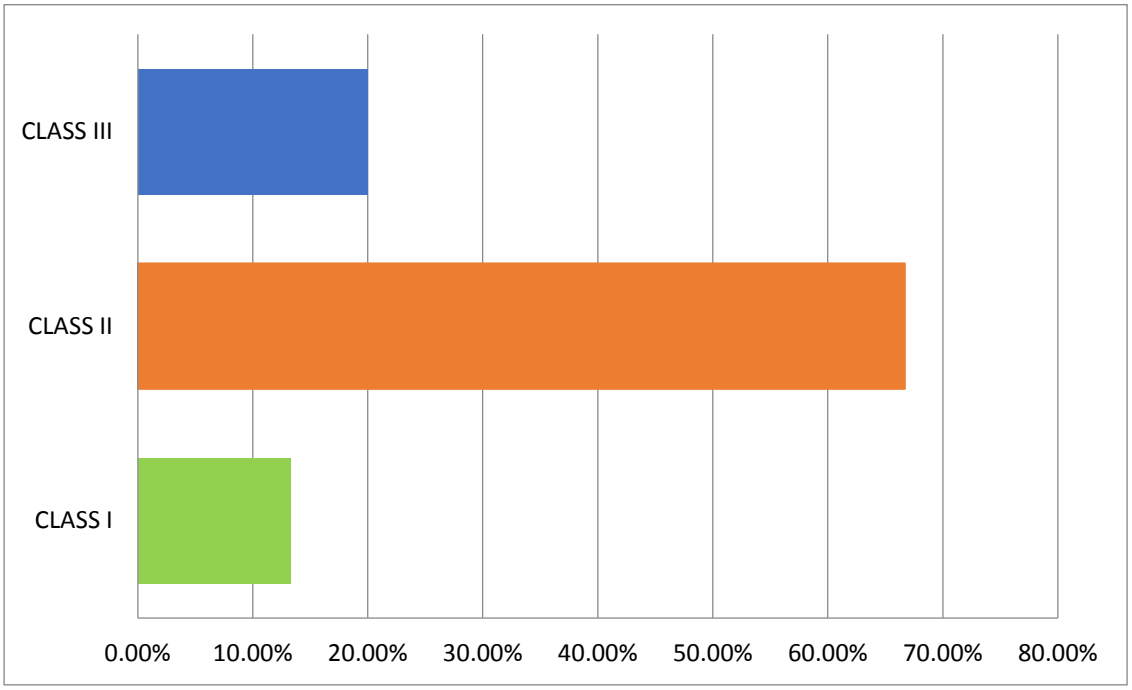
GRAPH 2: FREQUENCY OF IMPACTED 3RD MOLARS



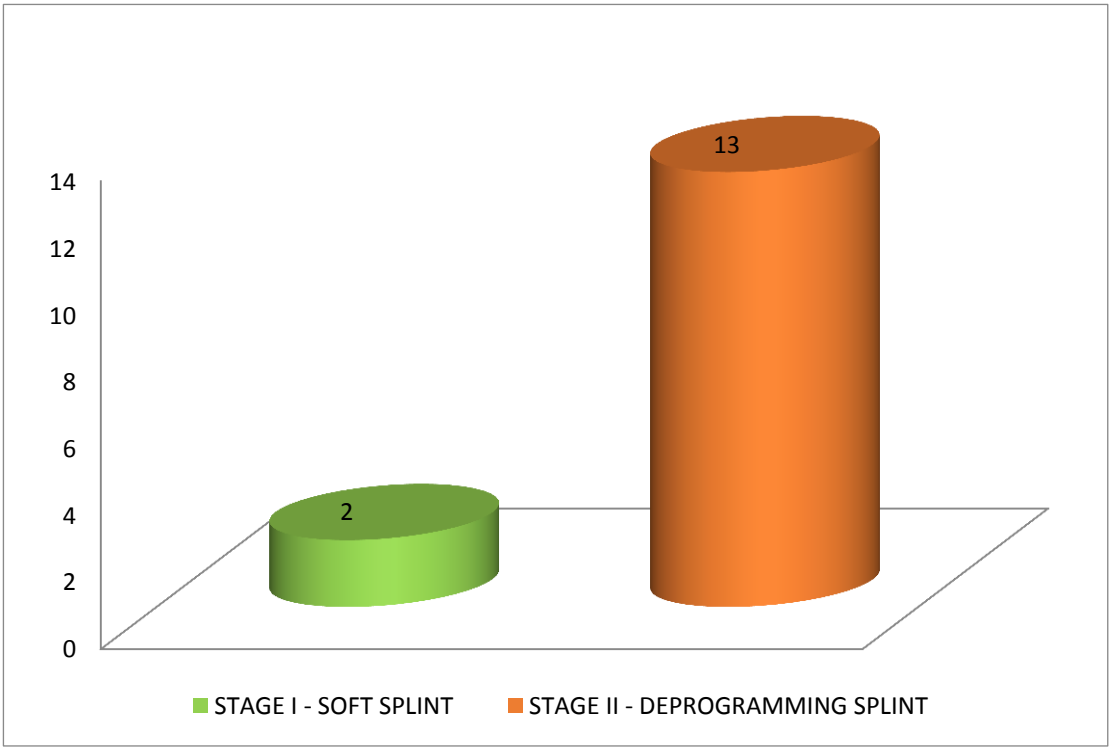
GRAPH 3: PRESENCE OF PARAFUNTIONAL HABITS



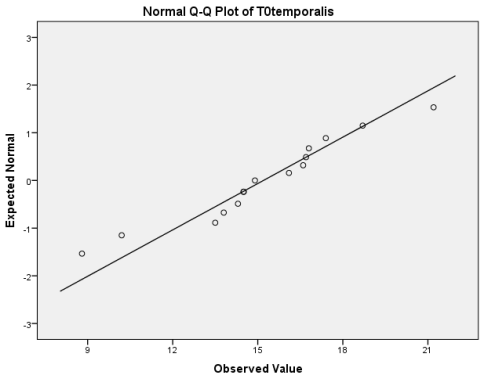
GRAPH 4: DISTRIBUTON OF ANGLE'S MALOCCLUSION

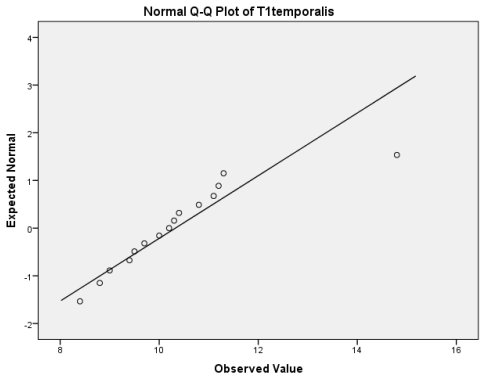


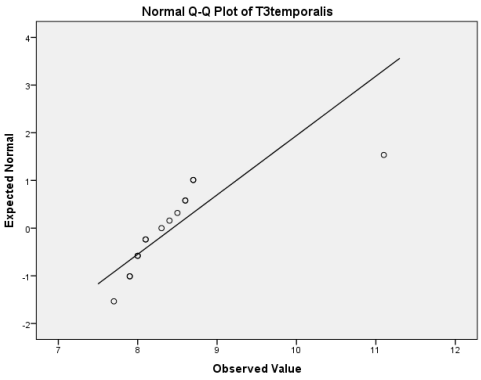
GRAPH 5: WILKE'S STAGING AND TYPE OF SPLINT

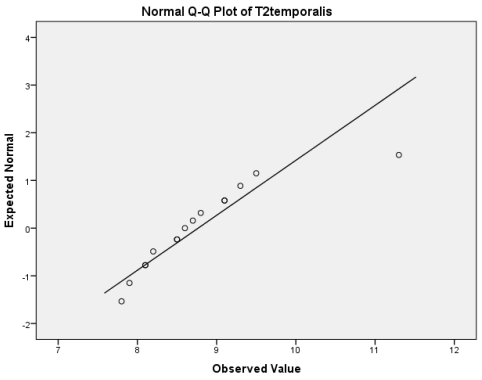


GRAPHS 6 : TEMPORALIS TRANSDUCER ANALYSIS

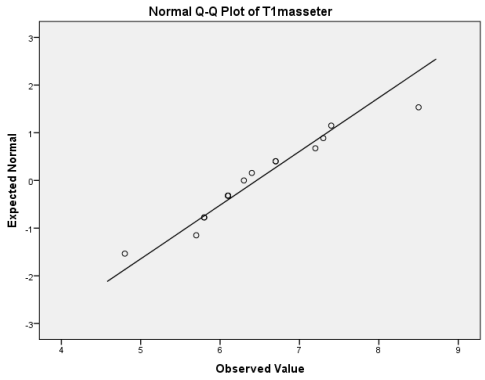


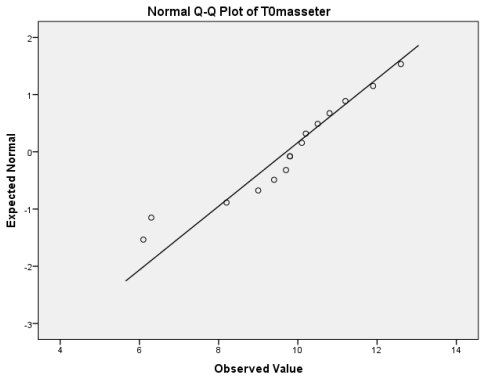


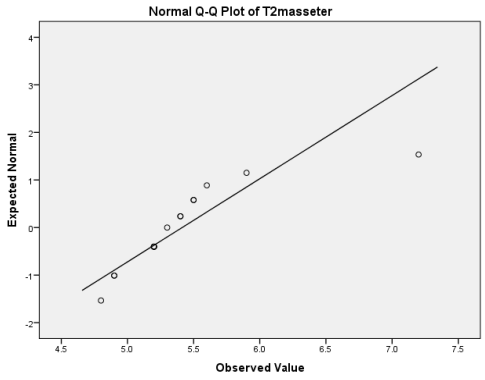


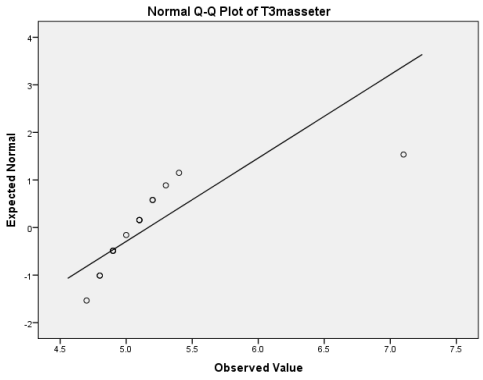


GRAPHS 7: MASSETER TRANSCUER ANALYSIS

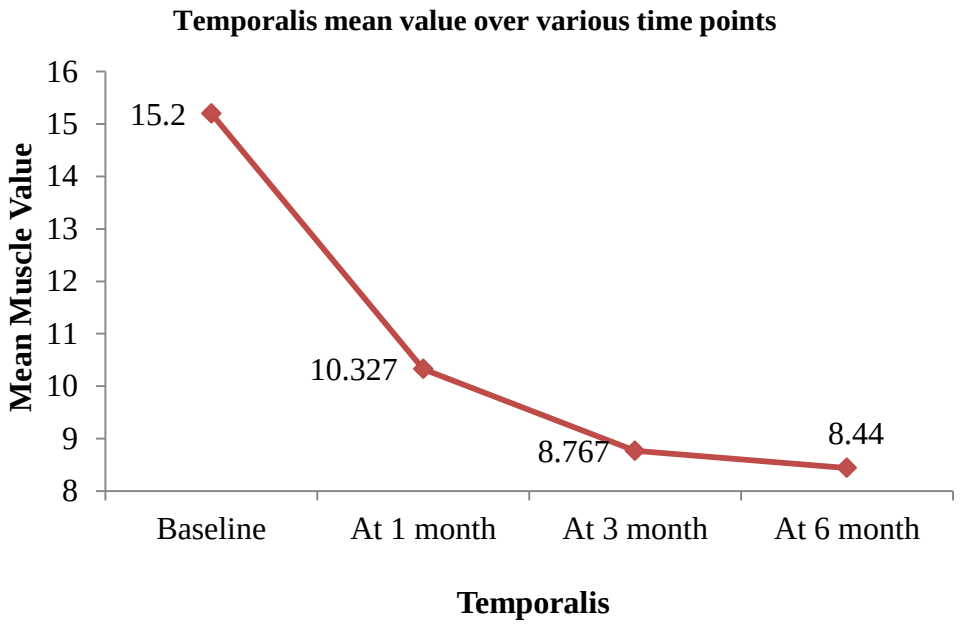




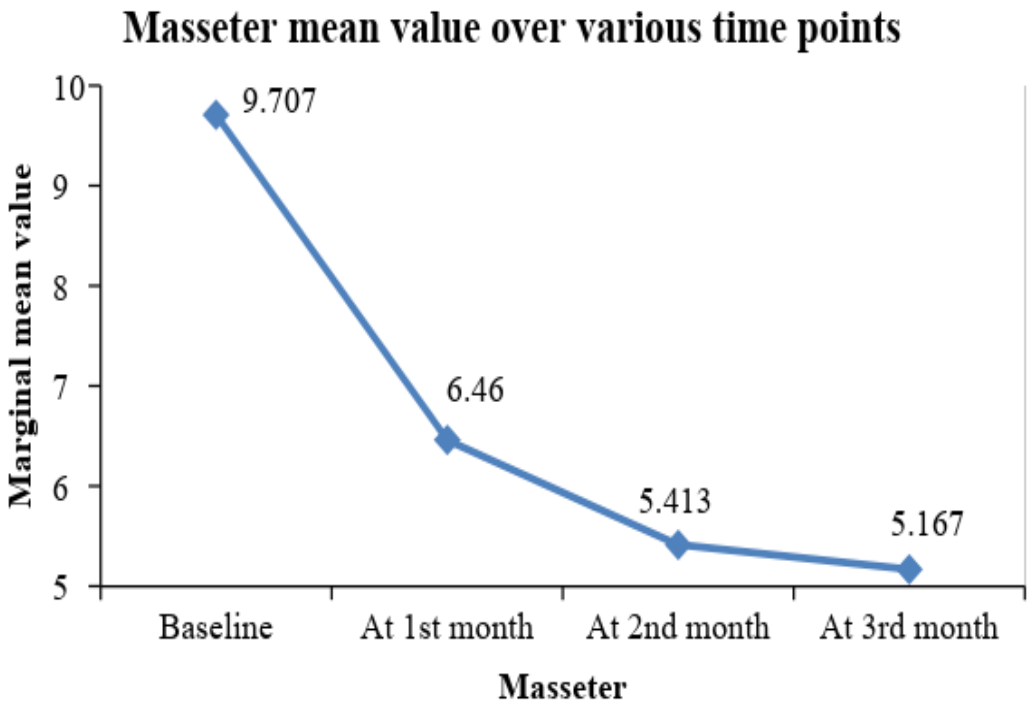




GRAPH 8: MARGINAL MEANS – TEMPORALIS MUSCLE



GRAPH 9: MARGINAL MEANS – MASSETER MUSCLE



Discussion

DISCUSSION

Temporomandibular joint dysfunction is a very common disorder and is considered the 2nd most common cause of orofacial pain after odontogenic pain which has the potential to produce persisting (chronic) pain. It is a condition characterized by an array of symptoms like pain in mouth opening, pain in orofacial region, TMJ sounds with or without pain, restriction of mouth opening, deviation or deflection of mandible on opening and pain or tenderness in TMJ region, orofacial muscles and other associated structures. The etiology of TMJ disorders is complex and multifactorial. The causes for TMD include initiating factors, perpetuating factors and predisposing factors like Loss of posterior teeth, parafunctional habits, stress, anxiety/depression, abnormal occlusion and adverse oral habits.[46] TMD's have a strong physiological and psychological impact on quality of life. **Bitiniene et al 2018** in a review of 320 publications found a direct correlation between TMJ disorders and quality of life, the statistical analysis revealed psychological and social ailments caused by TMD result in a lower quality of life.[47]

In this study of 15 participants 66.7 % were women and men accounting to 33.3 %, this result of women being affected more than men is similar to the prospective study by ***Bora Bagis et al 2012*** in which out of 243 participants171 were women constituting about 70.6 % of the study population[48] and ***Manfredini et al in 2017*** made similar observations in his study of 433 patients where women were around 73.2 % of the sample

population.[49] Sexual hormones, especially estrogen, perform an important role in pain sensitivity, even in muscles of mastication and TMD pathogenesis, the pain threshold and its tolerance vary according to menstrual cycle phase. As estrogen is a risk factor for TMD and other craniofacial pain conditions, studies with animals and humans have showed it can have peripheral and central action in pain modulation. It has also been shown that sexual hormones, majorly estrogen receptors, regulate sensitivity of trigeminal neurons or that they have some influence on the pain pathways of the trigeminal nerve.[50]

The mean age of the patients with TMJ dysfunction in this study was 30.86 years and 47 % of the population was between 27 – 35 years of age. Earlier studies did not support the concept of age-related differences in neither the presence of specific joint sounds nor in the presence or prevalence of TMJ dysfunction as a whole. In these earlier studies occurrences of headaches, pain, joint symptoms and associated structures discomfort or pain showed a uniform pattern between different age groups and no significant differences were found.[51,52] Recent studies state that older subjects have a higher prevalence of objective signs like joint sounds when compared to younger subjects who had a higher prevalence of subject signs like pain which lead them to taking treatment.[53,54] ***Guaradanardini et al in 2011*** has stated that advanced stages of disorders are more seen in age groups over 52 years and mean age group of

muscle incoordination and disc displacement is between 30 and 40 years of age.[55]

80 % of the sample population had impacted third molars present. It has long been speculated third molars could also act as precipitating factors for TMJ dysfunction.[56] It is still an inconclusive opinion to prophylactically remove third molars due to the risks associated with surgery.[57,58] In this study we favored the removal of impacted third molars prophylactically unless they were in normal occlusion, as in line with our thoughts none of the patients in the study had aggravated their dysfunction following the removal of the third molars. ***Huang et al in 2008*** performed a retrospective study of 2217 pairs of third molars in patients who had underwent extraction and there was no statistically significant relation between third molar removal, severity of impaction and development of TMJ dysfunction following the removal. But in patients lesser than 21 years of age who underwent all four third molar removal in a single sitting chances of developing TMD's were elevated by 23 %.[59] In our study, though the third molars which were not in occlusion are removed, bilateral extractions or surgical procedures were not carried out.

Harshali Fale et al in 2018 conducted a short span study in Maharashtra, in 200 adolescents. In those who had signs and symptoms of TMD, 92% of the affected population had some form of parafunctional habits.[60] In this study 80 % (12 participants) of the study population had a history or signs of parafunctional habits. Study done by ***Lobbeezoo et al*** &

Respetro C et al had stated that "Bruxism, clenching/grinding of teeth, nail biting, object biting, forward thrust of mandible as parafunctions".[61, 62] Hence it is extremely necessary to consider parafunctional habits as risk factor and initiaing factor for temporomandibular dysfunction as they act as triggering points due to their effects on the stomatognathic system.

Birgit Thilander et al in 2002 stated that significant associations were found between different signs, and TMD was associated with posterior crossbite, anterior open bite and Angle's class III malocclusion.[63] This was contradictory to the findings in our studywhere in 66.7 % of the sample population had Angle's class II malocclusion and only 13.3 % of the sample population had Angle's class III malocclusion. This could be owing to the small sample size in this study and maybe involving a larger volume of patients could provide us with a different result and it could also be due to the ethnicity and population demographic as the people of Sweden tend to have a more frequency of Class III relationships than in India. ***Manfredini et al in 2017*** put forward that it is the end of era in relating TMD's and nature of dental occlusion after a literature review as there is no ground to hypothesize the same and has encouraged dental clinicians to move forward and abandon the old-fashioned gnathological paradigm.[49]

In this study 86.6% of the population with Wilke's stage II whereas only 13.4 %reported in the early stage I of internal derangement. This could be owing to fact that patients presented themselves to the department of maxillofacial surgery only after they developed episodes of pain or some form of discomfort. Pain over the TMJ region, associated muscles of mastication or other facial muscles is mainly due to adverse habits, psychological factors like stress, anxiety and depression. All of these etiological factors lead to an imbalance in the masticatory system. This in turn reduces the patient's tolerance to changes in the masticatory system overtime which manifests itself as muscular pain, joint pain, joint stiffness with or without clicking of the joint. These findings are similar to the ones made by ***Ferriera et al,*** his study reveals more than half the sample population presenting themselves with pain as the primary complaint.[50]

The Fonseca Anamnestic Index (FAI) is a patient reported outcome instrument wherein the answers were given by the assessed individual. The RDC/TMD though widely accepted and standardized diagnostic tool for TMD is difficult to administer owing to its length and assessor training requirement, contradicting to this the FAI is easy to administer and does not require assessor training at the same time being highly sensitive, effective and accurate.[64] In this study out of the 15 participants the minimum FAI score was 25 and maximum FAI score at 65, thereby all the participants of this study were only in the mild to moderate stage of TMD and did not require invasive

intervention. ***Juliana alvares et al*** in a study involving 700 Brazilian women has stated that the FAI is a scale proposed to measure the severity of TMD's construct and has shown that the FAI has adequate validity and reliability.[65]

The Visual Analog Scale (VAS) is a subjective method of evaluation of the patient's pain characteristics that cannot be measured directly. It is a commonly used psychometric response scale in many questionnaires. In this study VAS was recorded at the time of presentation of the complaint and 1 month following conservative therapy. It was noted that the mean score of the 15 subjects dropped from 6.2 to 2.06 giving us a clear indication that the treatment has been effective in alleviating discomfort and pain in the study subjects. The VAS score showed correlation with FAI values and Wilke's staging of the TMD. Patients in moderate stages of TMD provided higher VAS values on presentation; similarly these patients had a higher FAI score.

A muscle force transducer was used in this study to evaluate the muscle activity in patients with TMD before and after conservative therapy.

The maximum value at T_0 for the temporalis muscle was 21.2 and minimum was 8.8, with a mean of 10.327. The maximum value at T_0 for the masseter muscle was 12.6 and minimum was 6.1 with a mean of 6.46. The higher values at time of presentation with complaint were seen in patients in the moderate stages of TMD (Wilke's II) whereas the lower values were seen in patients with milder stage of TMD (Wilke's I). This could be owing to the

fact that pain is generally developed at the later stages of disorder when a muscle in-coordination develops and in the earlier stages muscle activity is not affected severely. But it was interesting to note that that even in the earlier stages of TMD muscle activity was increased and was not within the normal limits. Thus, we can say that a subclinical increase in muscle activity can be present in all patients with even early stages of TMD. It was also clearly evident that temporalis activity was more pronounced than the masseter activity which could also be clinically correlated as most of the patients primarily complained of headaches or pain in the temple region along with other complaints of TMD's. ***Schmitter et al in 2018*** put forward that chronic stress was seen to be associated with increased level of temporalis activity during sleep in his electromyography study in 45 female participants.[66] Stress is considered as one of the primary precipitating factors of TMD's, thereby this could also be the primary reason for the higher values of temporalis activity.

The maximum value at T_1 for the temporalis muscle was 14.8 and minimum was 8.4, with a mean of 8.76. The maximum value at T_1 for the masseter muscle was 8.5 and minimum was 4.8 with a mean of 5.413. The T_1 values in both the temporalis and masseter muscle showed the most prominent change after splint therapy indicating that the management technique for the TMD was effective. All of the patients except one showed a prominent improvement from their condition with the start of splint therapy irrespective

of the type of splint used. These findings correlate well with ***Alajbeg et al 2003*** who documented the effect of occlusal splints on the muscles of mastication using electromyography and showed the improvement in activity after occlusal splint therapy.[67] ***Carlson et al 1979 Sheikholeslam et al 1980, Holmgren et al 1985*** have put forward that both at rest and maximal clenching the activity of temporalis muscles decrease after insertion of stabilization splint[68-70] but contradictorily ***S Canay et al in 1998*** stated that after splint therapy the changes in the muscle activity were insignificant.[71]

The values at T_2 and T_3 for both the temporalis and masseter muscle do show change with continued usage of the splint but clinically cannot be very well correlated as majority of the changes which resulted in clinical effects like loss of pain, obtaining normal mouth opening, resolution of clicking sound had occurred within one month of use of the occlusal splints. But interestingly, the normality of muscle activity was attained only after usage of splints for at least 3 months in patients with Wilke's II stage of internal derangement whereas the normality in muscle activity was attained after one month of usage of occlusal splints in patients with Wilke's I stage of internal derangement.

In one of the 15 patients included in the study diagnosed as Wilke's II stage of internal derangement with a FAI score of 65 (Highest in the study), the VAS score did not improve prominently after splint therapy. Though the T_0 values dropped significantly at T_1 for the temporalis and masseter muscle

the muscle activity did not revert back to normality even after continuous usage of splint therapy till T_3. This could be due to a more advanced stage of the disorder which has not been diagnosed properly or due to inaccurate fabrication of splint which has not relaxed the muscles completely. If advanced TMD is present conservative management will not be effective and the patient will require a more invasive option like arthrocentesis or prolotherapy.

On the basis of the results obtained we can say that when diagnosed correctly conservative management can be an efficacious mode of treatment of TMD's if caught at the right stage and when diagnosed accurately. The actions of splints are most prominent in the first month of usage but they aren't supposed to be discontinued with absence of clinical findings as continuous subclinical effects, though minimal, are seen and are to be continued until the muscular activities revert back to normality. The muscle force transducer is an efficient and handy tool not only to assess the severity of muscle activity in TMD's but can also be used to determine the duration of splint therapy required and as an educational tool for the patient to make him/her understand the scenario at hand.

The limitations of this study are that, the sample size was not large enough to obtain a uniform distribution though satisfactory results were obtained; A 3T MRI will provide more accurate data than a 1.5T MRI which has been used in this study thereby eliminating a chance of misdiagnosis; If

electromyography was done more specific muscle activity data could have been obtained but at the same time the transducer used in this study was a chair side equipment which provided efficient data on muscle activity and is more feasible than an electromyogram.

Summary and Conclusion

SUMMARY AND CONCLUSION

Temporomandibular joint disorders are one of the most common causes of orofacial pain. These disorders have a female predilection and are more commonly seen in the middle-aged population. Para functional habits, psychological factors and impacted third molars are common predisposing, precipitating or initiating factors of TMD's. TMD's are closely related to patients with an Angle's Class II malocclusion. Magnetic resonance imaging (MRI) continues to be the gold standard for diagnosis of internal derangement of the TMJ.

The transducer is an efficient, easy to handle and portable chair side device which can be used as a diagnostic aid and also allows the clinician to determine the duration of conservative management. It also allows for educating the patient on the nature of disorder and time required to provide him/her with a satisfactory treatment outcome.

As seen in this study occlusal splints have a prominent action on the muscles of mastication which are closely related to the TMJ and can still be considered as the first line of therapy of conservative management for patient's in the early stages of TMD.

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Annexures

ANNEXURE I

RAGAS DENTAL COLLEGE & HOSPITAL
(Unit of Ragas Educational Society)
Recognized by the Dental Council of India, New Delhi
Affiliated to The Tamilnadu Dr. M.G.R. Medical University, Chennai
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TO WHOM SO EVER IT MAY CONCERN

Date: 07-01-2019,
Chennai.

From,
The Institutional Review Board,
Ragas Dental College and Hospital,
Uthandi, Chennai-600119.

The Dissertation topic titled **"EFFECTS OF OCCLUSAL SPLINTS ON THE ACTION OF MUSCLES OF MASTICATION IN PATIENTS WITH TEMPEROMANDIBULAR JOINT DYSFUNCTION SYNDROME"** Submitted by **DR. AJIT C** has been approved by the Institutional Review Board of Ragas Dental College & Hospital.

Dr. N S Azhagarasan, M.D.S
Member Secretary,
Institutional Ethical Board,
Ragas Dental College and Hospital,
Uthandi, Chennai-600119.

ANNEXURE II

URKUND

Urkund Analysis Result

Analysed Document: EFFECT OF OCCLUSAL SPLINTS ON THE MUSCLES OF MASTICATION IN PATIENTS WITH TEMPOROMANDIBULAR DYSFUNCTION SYNDROME - PLAGIARISM CHECK.docx (D47068583)
Submitted: 1/21/2019 12:49:00 PM
Submitted By: ajit.c1993@gmail.com
Significance: 4 %

Sources included in the report:

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http://paperity.org/p/80474695/occlusal-stabilization-splint-for-patients-with-temporomandibular-disorders-meta-analysis
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